POWER PLANT ENGINEERING

Established Over 31 Years

VOL. XXXI CHICAGO, DECEMBER 15, 1927 No. 24

Annual Review Number

Page

Large Units Mark Progress in 1927.....1300
General Discussion of Power Plant Developments in the Field as a Whole; Tendencies, it is Pointed Out are Toward Larger Units in all Types of Equipment and Further Refinement of Principles Adopted in Recent Years.

Representative Power Stations of 1927.....1301

Tendencies in Boiler Room Practice. By John Hunter...1303
A Discussion of Recent Boiler Developments; Tracing the Increase in Boiler Pressures from 200 lbs. to Those of 650 and 1400 lbs.; All Phases of Boiler Room Practice are Considered, Including Reheating, Fuels and Fuel Burning Equipment, Furnace Practice, Air Preheaters and Economizers, Etc.

Fuel Burning Methods Show Steady Progress.....1307
Stoker Practice; Control and Heating of Air Supply; Pulverized Coal Practice; Type of Burners; Methods of Pulverizing; Drying; Coal and Ash Handling.

Furnace Design and Performance Improve.....1310
Furnace Volume Ratios; Water Cooled Walls, Application of Pulverized Fuel to Existing Furnaces; Removal of Cinders; Use of Preheated Air; Fan Practice and Draft Control Diagrams of Representative Boiler and Furnace Installations.

Tendencies in Boiler Plant Operation.....1313
Trends in Size and Capacity of Boilers; Savings Effected by Modern Equipment; Materials of Construction; Principles of Design; Effect of Water Walls on Performance; Superheater Practice; Cleaning of Boiler Surfaces; Gas Temperatures.

Conserving Heat Increasing in Importance.....1315
Discussing the Application of Economizers and Use of Preheated Air; Types of Economizers; Methods of Cleaning; Advantages of Preheating Air; Location of Preheaters and Economizers.

Combination Water Treatment Methods Prevail.....1316
Effect of Higher Pressures and Ratings on Feed Water Problem; Use of Deaerators and Evaporators; Effect of Blowing Down; Deconcentrators; Feed Water Temperatures in Use; Sampling and Testing.

Matured Practice in Steam Turbine Plant Design. By James W. Parker.....1318
The Chief Engineer of the Detroit Edison Co. Discusses the Essentials of Good Steam Turbine Practice; Simplicity of Layout; Repetition of Arrangement and Interchangeability of Parts are Some of the Factors Involved.

Stage Bleeding Dominates Station Heat Balance.....1321
Use of Air Preheaters and General Adoption of Motor Driven Auxiliaries Increases Utilization of Bled Steam with Corresponding Increase in Thermal and Economic Efficiency; Flow Diagrams of Representative Stations are Included.

Limit of Turbine Development Not in Sight.....1324
Importance of 1200 Lb. Turbines; Prospects for the Mercury Turbine; Stage Bleeding; Trend in Size of Units; Use of Steam Reheaters; Speeds.

Varied Condenser and Auxiliary Demands Met.....1326
Performance and Use of Single Pass Units; Piping Arrangements; Constructional Features; Sizes in Use; Surface Per KW. Steam Flow; Types of Packing; Methods of Driving Auxiliaries.

Tendencies in Hydraulic Power Development. By L. F. Harza 1329
An Interesting Discussion by the Chicago Consulting Engineer of the Factors Involved in the Economic Development and Operation of Hydro-electric Projects.

Trends in Electrical Design of Power Plants. By R. E. Argersinger 1332
Bus Arrangements; Auxiliary Supply; Generator Sizes and Voltages; Winding Arrangements; Excitation; Transformers; Oil Circuit Breakers; Switchboards; Conductors and Supports; Structural Design.

Electric Generators Reach 100,000 K.W. Mark.....1334
Sizes of Recent Large Units; Speeds and Frequencies; Generator Voltage Practice; Features of Construction; Voltage Regulation; Ventilation and Cooling; Use of Hydrogen for Cooling; Winding Connections.

Switching and Transformer Practice.....1337
Trend in Bus Design; Isolated and Group Phase; Armorclad Switches; Methods of Bus Protection; Transformer Developments.

Developments in Transmission Practice. By H. R. Summerhayes 1340
Developments in the transmission of electric power have been rapid and many during recent years. Mr. Summerhayes takes up, The Use of Direct Current, Lightning Protection, Interconnection, Control of Power Factor, Stability and Distribution Systems.

Field for Diesel Power Expands. By J. G. Oetzel.....1343
A discussion of new applications and developments in the Diesel Engine field. Mr. Oetzel discusses the development of large as well as small high-speed Diesels.

Recent Developments in Refrigeration. By Terry Mitchell 1346
Types and Designs of Compressors in Use; Use of Carbon Dioxide; Condensers; Ice Making Systems.

Letters Direct from the Plant: Superheating Exhaust Steam Rarely Pays; An Unusual Voltage Complaint; Installing Telephone Lines in India; Drop Cover Over Steps Avoids Accidents; Heating Feedwater to More Than 212 Deg.; Protection Permits Manipulation of Hot Screw Driver; Rubber Shod Ladder Feet. Illustrated 1349

Questions and Answers: Use of Freezing Tank as Ammonia Condenser; Bumped Heads for Pressure Drums; SO_2 as a Refrigerant; Change of Eccentric Sheave Diameter; Alters Throw; Leaks in Back Arches Prevented by Use of Asbestos Plaster; Locating Barometers for Pressure Measurement; Gasket in Air Pump Causes Trouble; Comparative Heating Values of Coke Fuels. Illustrated.....1352

Editorial Comment: Higher Pressures and Temperatures; Electrification of the Coal Field.....1354

Off Duty 1355

Jeffrey New Portable Scraper. Illustrated.....1356

Segment Roll Coal Pulverizer. Illustrated.....1356

Pulverized Fuel Extension Furnace for Small Boilers. Illustrated 1357

Master Motor Grinder. Illustrated.....1357

F H. Wells Dies.....1358

News Notes 1358

Books and Catalogs.....1359

EDITORIAL STAFF

ARTHUR L. RICE, Editor
R. E. TURNER, Managing Editor
A. W. KRAMER, Associate Editor
CHESTER R. EARLE, Associate Editor
RICHARD H. MORRIS, Associate Editor
EDWARD J. KUNZE, Associate Editor

Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 150 Nassau Street

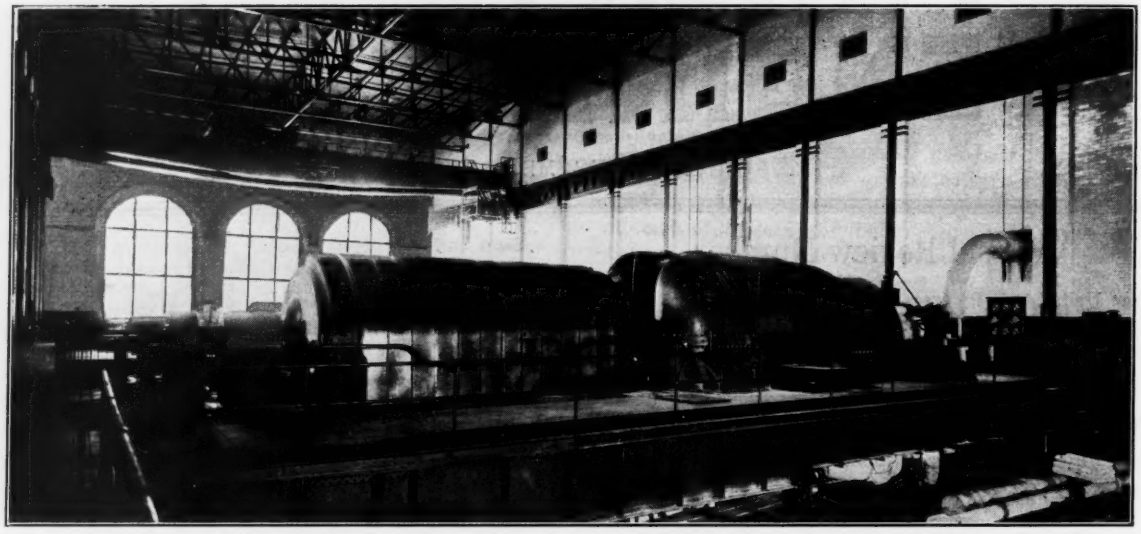
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright, 1927, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this Issue 23,100



Large Units Mark Progress in 1927

TENDENCIES IN THE POWER PLANT INDUSTRY ARE TOWARD LARGER UNITS AND FURTHER REFINEMENT OF PRINCIPLES ADOPTED IN RECENT YEARS

PROGRESS IN THE power plant industry during the past year has been in the further development or refinement of the many new principles which have been disclosed during recent years rather than in the introduction of any startlingly new processes or equipments. Considerable experimental work is being done in all branches of the industry and as fast as new methods prove commercially successful they are being adopted in new power stations.

Much of the experimental work, however, is being conducted in new portions of existing plants or on special equipment installed in old plants for the primary purpose of determining its commercial possibilities. Such, for instance, is the pulverized coal installation at Calumet Station in Chicago or the mercury vapor turbine installation at Dutch Point Station or the well-type turbulent burners at Huntley Station in Buffalo. It is for this reason that a survey of equipment installed in the new power plants constructed during the year will not indicate the most recent developments. The list of stations on which data is presented in this issue, therefore, can not be used as a basis for forming conclusions as to the most recent developments in the power plant field. It is presented rather to show the practice in the average new plants being constructed at the present time. With one exception all of the stations listed are new, that is, they were placed in operation within the past 18 months. The exception is Lakeside. Lakeside, although an old plant, was included because of the installation of the 1400-lb. turbine and which, we believe, is of exceptional interest.

DEVELOPMENT IN COMBUSTION EQUIPMENT AND METHODS

During the year the use of water-cooled furnace walls has increased rapidly and they are being used in furnaces burning all types of fuels by various methods. Use of turbulent burners is also on the increase, the installation at Bayside being typical of the trend. An interesting tendency is the use of this type of burner in the industrial power plant where they are applied in adapting pulverized coal to existing furnaces. One manufacturer has developed a small well-type furnace for h.r.t. boilers.

While improvements and simplifications have been made in the central preparation for pulverized coal, the trend toward the unit mill system noted last year is growing stronger, especially in the industrial field.

Rates of combustion have increased during the year, the average now being between 15,000 and 20,000 B.t.u. per cu. ft. per hr. Ratios of furnace volume to boiler heating surface remains about the same as last year—a little larger if anything—but the increased rates of heat liberation obtained with them decrease their effective size.

With stokers, water-cooled walls have led to refinements in furnace design, while the constant increase in the size of boilers has demanded an ever-increasing size of stoker, particularly in length. Means for more exact control of air distribution in unit sections of both underfeed and chain grate stokers have been devised, these controls in some cases operating automatically. Stokers are being developed to use preheated air to about 400 deg. and even to a maximum of 600 deg., although in most cases 300 deg. seems to be about the limit at present.

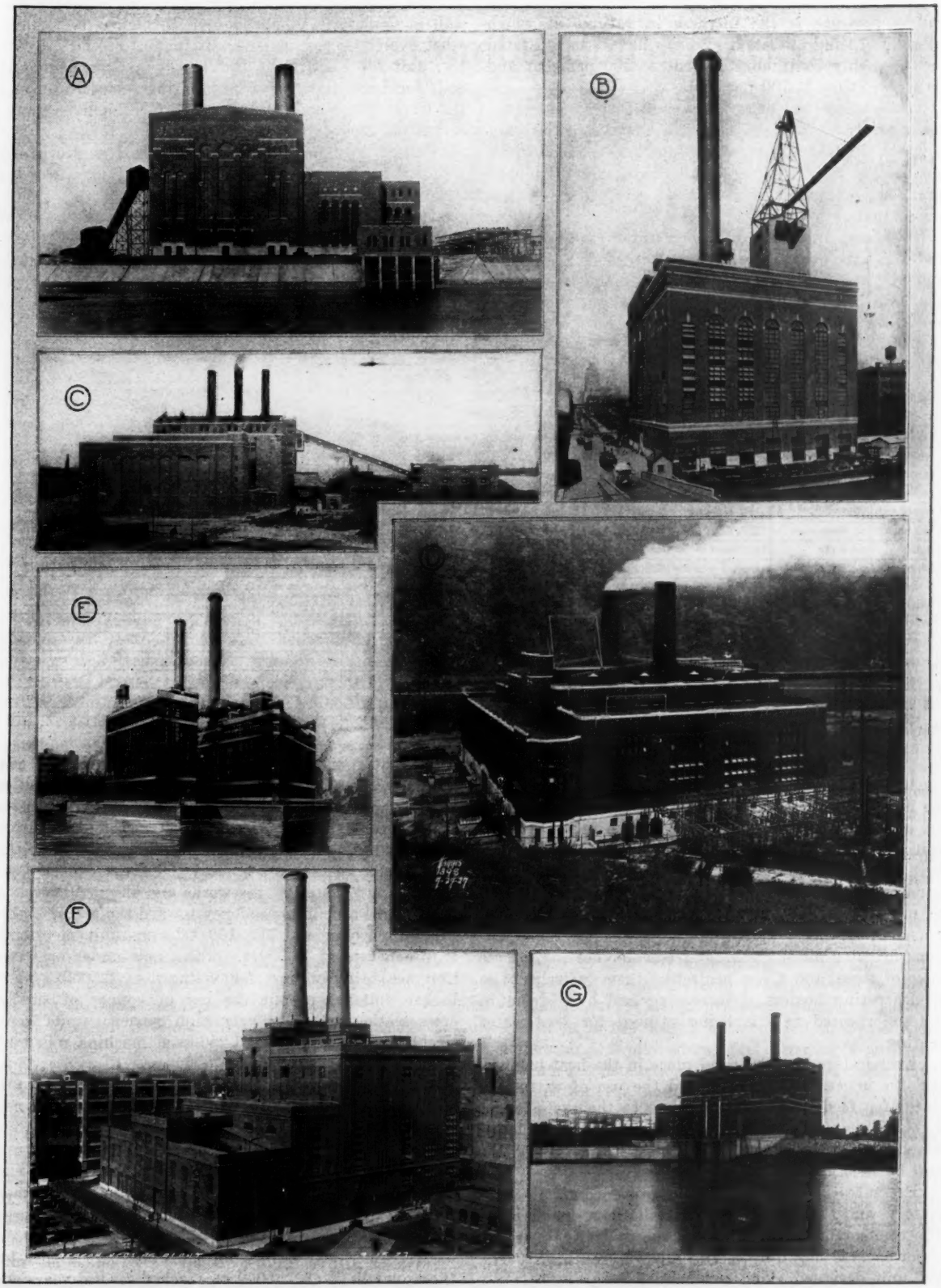
Methods of removing fly ash from the flue gas of pulverized coal furnaces are receiving much attention and several new types of equipment have recently been placed on the market for this purpose.

STEAM GENERATING EQUIPMENT

Boilers are still increasing in size and a number of exceptionally large units have been installed; those at Beacon Street, for instance, have a rated capacity of 4000 b.hp. with a total heating surface of 42,370 sq. ft.

Operating pressures also have increased but not at the same rate as in the previous few years. The 1200-lb.

Representative Power Stations of 1927



A. The Des Moines Station of the Des Moines Electric Light Co. B. Kips Bay Station, New York City's new central heating plant. C. Morrell St. Station at Detroit, Michigan. D. Stanton Station, West Pittston, Pa. E. The East River Station of the New York Edison Co. F. Beacon St. Plant at Detroit, another modern central heating plant. G. Buck Steam Station at Salisbury, N. C. Buck Station is a new steam auxiliary to a hydroelectric power system.

installation at Edgar Station last year has been exceeded this year by the 1390-lb. unit at Lakeside.

Consistent with the general increase in size and operating pressure is the increase in ratings at which boilers are being operated. Boilers have been operated for reasonably continuous periods at 500 per cent and for a short time at 700 per cent.

Several installations of the so-called steam generator, consisting of a totally water-cooled furnace in the walls of which the steam is generated, have been made in industrial plants, one of these to operate at 800 lb. pressure. A few installations have also been made in central stations.

Tests and treatment of boiler waters are being introduced with greater accuracy and methods are becoming more standardized. Combination methods of treatment are being employed rather than confining treatment to a single system.

standard practice and the reheat cycle is being more widely adopted.

The largest unit of the year has been the 104,000-kw. unit at Crawford Avenue, although this has been somewhat overshadowed by the construction of the 208,000-kw. unit for State Line, the 94,000 tandem compound unit for Long Beach, the largest single shaft unit, and the 65,000-kw. single cylinder unit for Edgar, each the largest of their type yet constructed.

Condensing surface per kw. installed is decreasing steadily, the lowest being that at East River, where the ratio is .75.

In the electrical side of power stations, the trend of development during the year has been toward the construction of larger turbo-alternators. Some exceptionally large units went into operation and others, still larger, are under construction. Of the latter, the 100,000-kv.a. unit for Long Beach will be the largest

GENERAL DATA ON STATIONS

NAME OF STATION	DESIGNING ENGINEERS	COMPANY		LOCATION	TYPE PLANT	CAPACITY *		VOLTAGE		STEAM PRES. (GAGE)	FUEL	MAKE-UP	CONDENSING WATER
		HOLDING	OPERATING			PRESENT	ULTIMATE	GENERATED	TRANSMISSION				
LAKESIDE	THE MILWAUKEE ELECT. RY. & LIGHT CO.	WIS. ELECTRIC POWER COMPANY	THE MILWAUKEE ELECT. RY. & LIGHT CO.	MILWAUKEE, WIS.	CENT. STA. SYSTEM LOAD	167,000	230,000	13,800	22,400 132,000	1340	W.VA.-PULV.	LAKE MICHIGAN	LAKE MICHIGAN
BAYSIDE	SYLLESBY ENGINEER'S AND MANAGEMENT CORP.	STANDARD GAS & ELECTRIC CO.	WIS. PUB. SERVICE	GREEN BAY, WIS.	CENT. STA. STM. STANDBY FOR HYDRO	28,000	?	14,000	66,000	350 LB.	PULV. FUEL	EVAPORATED RIVER WATER	GREEN BAY OR FOX RIVER
STANTON	SARGENT & LUNDY, INC.	AMERICAN GAS & ELEC LIGHT CO.	CO. + PENN. POWER & JOINT OWNERS	W. PITTSTON, PA.	CENT. STA.	90,000	360,000	11,000 V.	66,000	625 LB	ANTHRACITE CULM STOKERS	SUSQUEHANNA R. OR DEEP WELLS	SUSQUEHANNA R.
EAST RIVER	THOS. E. MURRAY, INC. AND N.Y. EDISON	N.Y. EDISON	N.Y. EDISON	NEW YORK, N.Y.	BASE LOAD CENT. STATION	120,000	1,000,000	11,400 V.	28,980	360 LB.	BITUMINOUS - PULV.		EAST RIVER
MORRELL ST.	SMITH, MINCHMAN & GRYLLS	CITY OF	DETROIT	DETROIT, MICH.	MUNICIPAL	60,000	120,000	13,200	24,000	385 LB.	W.VA. BITUMINOUS PULVERIZED	CITY WATER	DETROIT RIVER
DES. MOINES	ILL. POWER & LIGHT CO.	NORTH AMERICAN LIGHT & POWER CO.	DES MOINES ELECTRIC LIGHT CO.	DES MOINES, IA	CENT. STA. SYSTEM LOAD	48,800	133,000	13,800	66,000	385	IOWA COAL - STOKER FIRED	DES MOINES R. OR WELLS	DES MOINES RIVER
BUCK	WM. S. LEE	DUKE POWER CO.	SOUTHERN POWER CO.	SALISBURY, N.C.	CENT STATION SYSTEM LOAD STANDBY	70,000	?	13,200	100,000	425	PULVERIZED COAL	YADKIN RIVER	YADKIN RIVER,
WHIPPANY	GENERAL ENGINEERING & MANAGEMENT CORP.	NATIONAL PUB. SERV. CO.	JERSEY CENTRAL POWER & LIGHT CO.	WHIPPANY, N.J.	CENT. STATION SYSTEM LOAD	20,000	40,000	6,600	33,000	325 LB	ANTHRACITE NO. 3 BUCKWHEAT	WELLS	WHIPPANY CREEK & SPRAY PONDS
LAUDERDALE	ELECT. BOND & SHARE CO.		FLORIDA POWER & LIGHT CO.	FT. LAUDERDALE, FLA.	BASE LOAD CENT. STATION	80,000	150,000	13,800 V.	66,000 V.	400 LB.	FUEL OIL	DANIA CANAL	DANIA CANAL
HARBOR POINT	THOS. E. MURRAY, INC.		UTICA GAS & ELECTRIC CO.	UTICA, N.Y.	CENTRAL STA.	37,500 KV.A.	188,000 KV.A.	13,800 V.		275 LB.	COAL UNDERFEED STOKERS	CITY MAINS	MOHAWK RIVER
NECHES	STONE & WEBSTER, INC.		GULF STATES UTILITIES CO.	BEAUMONT, TEXAS	CENTRAL STA.	21,000	300,000	13,200 V.		375 LB.	NATURAL GAS-FUEL OIL	NECHES RIVER OR CITY WATER	NECHES RIVER
KIPS BAY	THOS. E. MURRAY, INC.	NEW YORK STEAM CORP.		NEW YORK N.Y.	CENT. HEATING PLANT	1,950,000 LB STM/HR.	3,900,000 LB. STM./HR.	2,300 V		275 LB.	PULV. BITUMINOUS	CITY WATER	NO. CONDENSERS
BEACON ST.	THE DETROIT EDISON CO.	THE DETROIT EDISON CO.		DETROIT, MICH.	CENT. HEATING PLANT	18,537 B.HP.	50,000 B.HP.	4800 V.		175 LB.	W.VA. KENTUCKY & OHIO COAL - UNDERFEED STOKERS	CITY WATER	NO. CONDENSERS
MINNEQUA	WILFRED SYKES	COLORADO FUEL & IRON CO.		PUEBLO, COLO.	INDUSTRIAL	20,000	30,000	6600 V.		365 + 150 LB.	BLAST FURNACE GAS PULVERIZED COAL	RESERVOIR	SPRAY POND
MASSILLON	FREYN ENGINEERS CO.	CENTRAL ALLOY	STEEL CORP.	MASSILLON, O.	INDUSTRIAL	10,000		11,000 V.		275 LB.	BLAST FURNACE GAS PULV. COKE & COAL	WELLS	SPRAY POND
THREE RIVERS	MC CLELLAN & JUNKERSFELD AND A.H. WHITE	CANADIAN INTERNATIONAL PAPER CO.		ST. LAWRENCE R.	INDUSTRIAL	71128 HP	8128 BHP	NO. ELEC	GENERATED	135 LB.	FUEL OIL OR PULV. COAL		

* = CAPACITY IN KW. UNLESS OTHERWISE NOTED

Heat Balance

Almost universal use of motor-driven auxiliaries, the necessity for practically pure boiler feed water, and the application of the air preheater has influenced the heat balance during the past year. Stage extraction for feed water heating and for operation of the evaporators is now considered standard practice. There appears to be no definite treatment of the generator air cooler, generator oil cooler and ejector condensers. Some stations utilizing all of these for feedwater heating, others some of them, and a few neglecting them entirely. Use of deaerating heaters is increasing and bled steam in the superheated field is being utilized for feed water heating.

Evaporators have no fixed place in the heat balance, and the general trend is toward the use of extraction steam for feed water heating, even to the exclusion of some of the unavoidable low temperature heat losses which formerly were considered essential parts of the heat balance.

Pressures up to 1200 lb. have proven entirely satisfactory, and two new 1200-lb. installations are planned. The commercial importance and success of the mercury vapor cycle is shown by the installation of a new 10,000-kw. unit designed along commercial lines.

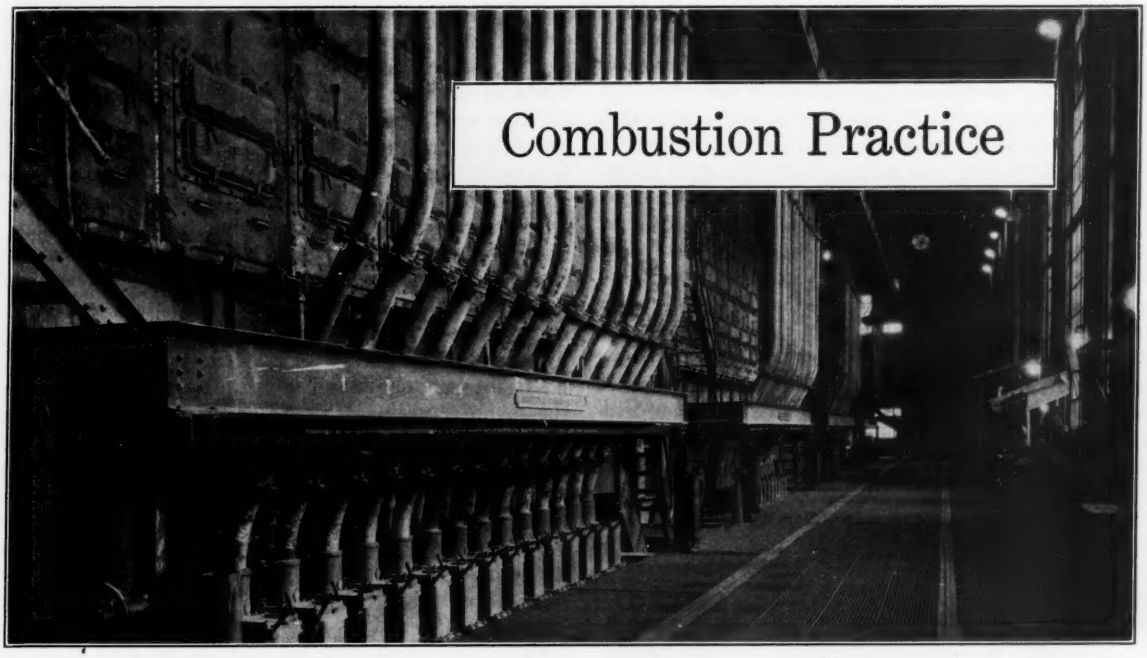
Temperatures remain about the same as last year, ranging from 700 to 750 deg. Stage bleeding is now

single-shaft generator unit ever constructed. In connection with the manufacture, shipment and installation of the large turbo-alternator there has been an extension of the use of skeleton frame construction for stators, which brings about a number of advantages. With this construction, generators up to 75,000-kv.a. capacity can be built and wound at the works and shipped complete.

There is a definite tendency toward the use of higher generator voltages. The 100,000-kv.a. unit mentioned is to generate at 16,500 v.; others now under construction are being wound for voltages of 22,000. These higher voltages permit the use of copper of smaller cross section, which in very high capacity units is desirable. In England a 31,250-kv.a. machine was built for 33,000 v.

Transformers, like generators, are still growing in size. During the year the largest artificially-cooled unit was built, this being a 66,667-kv.a., 25-cycle auto-transformer for the Huntley Station in Buffalo. This unit required 36 t. of steel and 17 t. of copper for its construction. The development of load ratio transformers reported last year has justified the claims for its growing importance.

Transmission voltages, on the whole, are higher but the upper limit of 220,000 v., reached several years ago, has not been exceeded and there is no immediate prospect of this being done.



Tendencies in Boiler Room Practice

A Discussion of Recent Boiler Developments, Tracing the Increase in Pressures from 200 to 650 and 1400 Lb. By John Hunter*

IN THE LARGE central station the unprecedented increase in the unit size of turbo generators has brought with it the problem in boiler room practice not only of a tremendous increase in steam demand, but also of higher steam pressure and temperature. Combined with these requirements, while the question of the more efficient thermal utilization of fuel in the generation of steam has become of increased importance, that of "Dollar Efficiency" is now of primary interest.

Not many years ago the maximum unit capacity of prime movers was 20,000 kw., and there are now several units in service of 100,000 kw., and several on order up to 200,000 kw. The operating pressure has increased from 300 lb. and 600 deg. F. steam temperature to 650 lb. and 750 deg. F. steam temperature. A few units are now in service, and others are on order between 1200 and 1400 lb. pressure, so that these units are now an assured commercial success and will undoubtedly come into further general use.

The parallel development in the boiler room is typified by the progress of one of the large Midwestern Public Utilities which in 1902 installed Scotch Marine Boilers with a maximum steam output per unit of 15,000 lb. per hr. In 1908 the Scotch Marine Boilers were replaced with water tube boilers fired by natural draft chain grate stokers, the maximum capacity of each unit being increased to 23,000 lb. per hr. These units were replaced in 1916 with a similar installation at higher pressure and with larger furnaces, fired by forced draft underfeed stokers with a maximum capacity per boiler of 33,000 lb. per hr., and in 1925 this capacity was increased to 50,000 lb. per hr. by the rearrangement of furnaces and the adaptation of the direct fired pulverized coal system. A new station built by this company about that time was laid out for various reasons with boiler units of a maximum normal capacity of 108,000 lb. per hr., and their most recent installation, made this year, has a maximum capacity of 230,000 lb. per hr. from one boiler unit in the same space. The boiler installed in 1902 operated at normal rating based on the so-called boiler hp. of 10 sq. ft. of heating surface. The units installed in 1927 will operate at 430 per cent of rating, based on the same unit of boiler horsepower.

That the old method of rating boiler horsepower on a square foot of heating surface basis is no longer satisfactory is generally appreciated, and work has been started to settle on some unit which will be more accurate and useful for comparison.

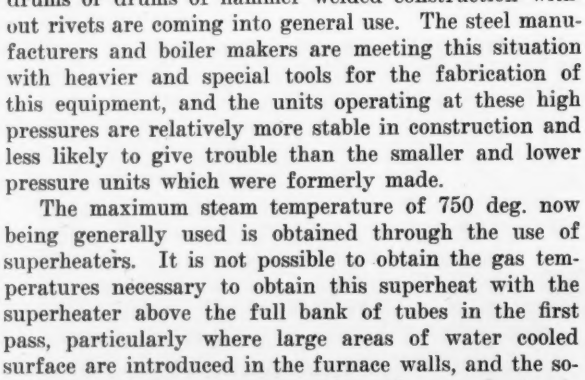
Increase in unit size and rating of operation indicated above, with higher steam pressures and temperatures, has brought many problems requiring careful consideration in the design, construction, and operation of boilers and superheaters, fuel burning equipment and furnace construction, and the necessary auxiliary equipment for the handling of coal and ashes, feed water and flue gases. The general principles have changed but little, but the refinements which have been made are almost without number.

The heating surfaces of the modern boiler are arranged much as they were 10 yr. ago and, while several forms of pipe boilers have been tried, the standard horizontal straight tube and so-called bent tube boilers with large drums overhead are still being used, the selection of a particular type for a given condition depending on the individual factors involved. Some

*Consulting mechanical engineer, St. Louis, Mo.

changes have been made in tube spacing and baffling with the view of obtaining better gas passages and more even distribution of heat. The higher boiler pressures involve the use of heavier gage materials for tubes and drums, and above 450 lb. pressure solid forged steel drums or drums of hammer welded construction without rivets are coming into general use. The steel manufacturers and boiler makers are meeting this situation with heavier and special tools for the fabrication of this equipment, and the units operating at these high pressures are relatively more stable in construction and less likely to give trouble than the smaller and lower pressure units which were formerly made.

The maximum steam temperature of 750 deg. now being generally used is obtained through the use of superheaters. It is not possible to obtain the gas temperatures necessary to obtain this superheat with the superheater above the full bank of tubes in the first pass, particularly where large areas of water cooled surface are introduced in the furnace walls, and the so-called interdeck arrangement where the superheater is



THE PULVERIZER ROOM OF A STATION USING THE CENTRAL SYSTEM OF BURNING PULVERIZED COAL

placed above the first four or five tubes in the first pass is now in general use. The gases at this point are high in temperature, and by a proper proportioning of the heating surfaces and gas passes, a uniform superheat is obtained through wide ranges in capacity. The use of the radiant type superheater has become quite general, the superheater elements being introduced into the side or rear walls exposed to the direct radiant heat of the furnace. Any desired degree of superheat can be obtained in this way, but with this arrangement the unprotected steel elements require careful design to prevent burning and warping, and in some cases water screen tubes have been placed in front of the radiant superheater for this purpose with splendid results.

Reheat Cycle Used with Reheat Boilers or Steam Reheaters

Where high pressures are being used the reheat cycle is being introduced, involving the passage of the steam through a portion of the prime mover where it drops in pressure and temperature, returning it to a reheater where it is brought back to the original temperature, and then passing it through another portion of the prime mover. These reheaters are of the direct fired or gas swept type, where the reheat elements are installed in the boiler proper in the path of the higher temperature gases, or are of the type which admits high pressure and high temperature steam through coils surrounded by the steam to be reheated. The latter method is a much simpler one as it eliminates the necessity of runs of large piping and many fittings which the gas swept or direct fired unit requires. Reheating not only makes possible higher cycle efficiency, but brings with it drier steam throughout the turbine, with consequent reduction in the mechanical erosion of the low pressure blades which takes place with the ordinary cycle due to the presence of water.

Higher pressures and temperatures have confronted the manufacturers of valves and fittings with another set of problems which have been adequately met and little difficulty is being experienced with this equipment in use up to 1400 lb. pressure and with the higher steam temperatures. The development of electric steel has been a factor in making this possible and a more or less general use is being made of the x-ray to insure soundness and homogeneity of the steel for these purposes. Standards for fittings and piping up to 1400 lb. have been passed which serve as a guide for both manufacturer and purchaser.

Fuel Burning Equipment

Increase of the boiler unit size and the operation of these units at high ratings with the requirement of efficient utilization of fuel have introduced many problems which the manufacturers of fuel burning equipment are meeting with remarkable success. The selection of the system for burning fuel is the result of study of the particular conditions surrounding each individual case, involving such factors as the fuel available, cost of fuel, size of units, plant load factor, etc. The selection should be based on the highest overall "Dollar Efficiency" for the completed station.

Under feed stokers have developed considerably, these having been lengthened out to increase the area on which coal can be burned, so that ratings as high as 500 per cent have been carried by boilers fired by this type of equipment. The deepening of the clinker grinder pit and the improvement of the clinker grinder have done much to reduce the combustible loss in the ash to a minimum. The stoker manufacturers are also making a great effort to eliminate as far as possible the stratification of gases in the furnace. These units, particularly where subject to automatic control, are maintaining in monthly operation very high standards of performance, notably on the high grade Eastern coals. The combustion chambers have been greatly increased in size over the last 10-yr. period, and this development has done much to make possible the high efficiencies which are being obtained at high ratings.

In the Midwestern field where the low grade high ash coals are available the subdivided wind box forced draft chain grate stoker is being widely used, even in the larger sizes, and is maintaining excellent standards of monthly efficiency. In the larger units where extreme widths of furnaces are encountered the chain grate stokers are built as two independent units, each extending half the width of the furnace, sometimes with a

bridge wall between in order to get away from the mechanical difficulties of the very wide stoker. Considerable data have been accumulated on the proper design of stoker arches, so that more rational design is possible at the present than was formerly the case. The different grades and classes of coal require very different treatment of the arch design. The admission of over fire air at the stoker arch is being quite widely used and serves not only to eliminate the smoke which formerly was made in large quantities, but also increases the efficiency of combustion by the elimination of uneven gas and air distribution in the furnace. Proper design of ash hoppers and gates has solved the problem of air infiltration at the rear of the stoker.

With the higher rates of combustion obtained due to the forcing of boilers to higher ratings, the necessity of water cooled walls in connection with both chain grate and under feed stoker settings has been appreciated, so that the use of side wall water cooling has become almost standard practice where high ratings are contemplated. The water cooled side walls for the chain grate stoker eliminate the difficulty of excessive side wall maintenance and also difficulties formerly experienced with clinker formation, particularly with the high ash, low fusion temperature ash coals. Rather heavy maintenance is still being experienced on the standard stoker ignition arches, and there is considerable room for improvement in this direction, probably through the design of arches sufficiently water cooled to prevent excessive maintenance, but which will still provide for ignition purposes. In the under feed stoker furnace, the bridge wall is also being water cooled and is eliminating difficulties formerly experienced at high ratings due to clinker adherence. The ventilated air cooled block is also being quite widely used in the furnace construction with the under feed stoker, and with considerable success.

Pulverized Fuel Practice

During the last 5 yr. a tremendous amount of knowledge has accumulated relative to the burning of coal in pulverized form and the refinement of the storage or bin and feeder system, the first method of burning pulverized coal to come into general use. The unit or direct fired system has also developed rapidly and indications point toward its being more extensively used, even in the large central station installation.

The unit system shows possibilities of tremendous reduction in total plant cost made possible by the smaller building space required, the elimination of the use of driers and the rather expensive transport system for the pulverized coal. The unit pulverizers have been highly developed during the past 3 yr., resulting in finer grinding of the coal with reduction in power consumption, reduction in maintenance cost, increase of the periods between necessary shut-downs for maintenance of equipment and increase of reliability. A considerable increase in the unit capacity of unit pulverizers has been made, and several units are now in operation up to 8 t. per hr. capacity. The pulverization obtained from these units is virtually the same as that which has been accepted as standard for the storage system.

In pulverized coal firing the demand for high efficiency has resulted in the use of higher CO_2 and this combined with the higher combustion rates per cu. ft. of furnace volume has resulted in much higher furnace temperatures with the serious problem of furnace maintenance. Air cooled walls were first used in an effort to reduce the cost of maintenance, but the trend was rapidly in the direction of the introduction of large areas of water cooling surfaces, connected directly in the boiler circulation. These surfaces, originally introduced for the purpose of eliminating side wall maintenance, were rapidly found necessary as a governing factor in determining the amount of heat which could be generated in a given furnace without slagging the ash in the entering boiler passes. Combustion rates with pulverized coal have increased from approximately 12,000 B.t.u. per cu. ft. per hour to 35,000 to 40,000 B.t.u. per cu. ft. per hr., indicating a fuel burning capacity of over three times what was considered possible not over 5 yr. ago. This has led to a relative reduction in the physical size of combustion chambers necessary for the firing of pulverized coal, or, viewed from another angle, the burning of larger quantities of pulverized coal in a furnace of a given size.

The extensive use of water cooled walls has brought out many variations in design, some of which are made up from bare tubes recessed in a thin brick wall with refractory between the tubes, others with so-called fins welded to the sides of the tubes, forming a continuous steel wall, still another with cast iron blocks bolted between the side wall tubes with an iron paste between the cast iron block and the tube itself for the purpose of giving intimate contact for heat transmission from the block to the tube. These cast iron covered blocks have also been made with refractory face for the purpose of maintaining temperatures for ignition purposes. This is not now believed a necessity in many cases, and because of the lower heat transmission through this form of covering, the efficiency of this type of water cooling is not as high as the bare tube construction. Many different designs of water cooling are being made and rapidly installed, and much valuable information is being obtained which will make possible more rational design of water cooled furnaces in the not far distant future.

The extensive use of water cooling has made possible a furnace construction which almost entirely eliminates the use of refractories, the water cooled tubes being backed with a relatively thin element of high efficiency insulation. This is very considerably reducing the loss due to radiation in the large boiler settings. The actual weight of the settings is also thereby greatly reduced.

Handling of ash in the pulverized coal furnace has been one of the most serious problems to be met in the development of this system of burning coal, particularly in the Midwestern district where the coal has an exceedingly high ash content of low fusion temperature. The ash accumulating on the bottom of the furnace has had a tendency to slag and clinker in large masses and until recently many engineers have condemned the system on this ground. The use of water floors and horizontal firing is apparently one solution of this extremely serious problem.

The advantages of introducing the air required for

combustion with the coal or close to the point of coal admission are becoming more and more apparent, as is the advantage of maximum turbulence at the burner and in the furnace. Burners of extremely high capacity have been and are being developed and units burning as high as 10,000 lb. of coal per hr. are coming into general use. It is recognized that the smaller the number of burners used per boiler the better will be the distribution of coal to these burners.

A problem which is assuming very great importance in connection with the use of pulverized coal is that of the elimination of heavy ash discharge into the atmosphere. This has become in some instances a decided civic problem and almost prohibitive legislation has been passed regulating its control. Many comprehensive efforts have been made to collect the pulverized coal ash from large central stations by the use of electrical precipitation, gas washing and mechanical collection in baffle and cyclone collectors.

Use of Air Preheaters

Use of air preheaters is perhaps the most striking and important development which has taken place in the boiler room in recent years and it is expected that the use of this piece of equipment will become as standard as that of the boiler itself. The forcing of boilers to higher and higher ratings results in higher exit gas temperatures. It is understood that the sensible heat in the flue gases is the major loss in the boiler room heat balance and the reduction in this loss was the logical step in the more efficient utilization of our fuel. While economizers had been used for many years for this purpose, the use of stage bleeding in the large central station for heating feed water has eliminated to some extent the necessity for this piece of equipment in the station heat balance. Whether or not the economizer will be retained in connection with the use of the air preheater is now a question to be answered by the study of the factors involved in each particular case, although it will be but rarely found that the installation of both the economizer and air preheater can be justified.

Advantages of the use of preheated air as a factor in the increase of the efficiency of combustion as well as a method of direct heat recovery are now well established. Preheated air up to 450 deg. is now being successfully used with chain grate and under feed stoker installations, and installations are now on order or being contemplated using air above this temperature. The desired degree of preheat is dependent on many factors which require in each case careful individual study, but the general trend points in the direction of the advisability of higher and higher air temperatures, particularly when used with pulverized coal firing. The extensive use of water cooled surfaces has made the use of preheated air not only possible but extremely advantageous, if not almost a necessity. The speed of ignition and combustion is greatly accelerated by the use of preheated air, making possible higher combustion rates per unit of furnace volume and, therefore, smaller furnaces.

With stoker firing the use of preheated air has introduced new mechanical problems and made advisable the special design of grate to admit the larger volumes of air for a given weight. This is still more or less of a problem which the stoker manufacturer will have to solve.

Manufacturers of forced and induced draft fans have kept pace with the demand for more efficient and larger equipment to meet the new conditions of higher pressures required for air preheater installations, and little is to be desired in this connection.

Automatic or semi-automatic control of the boiler unit, including all its component parts, presents a problem of tremendous importance with the growing size and complexity of these units and the appreciation of the fact that it is virtually impossible to control all the elements involved continually at anything like maximum efficiency. Several systems of complete control are available and in more or less successful operation. The difficulty with them lies in their complexity and the difficulty of maintaining them in operation continually at maximum efficiency. Their high initial cost has in the past prevented their more general use, but it is becoming more widely accepted that their installation is justified on a savings basis.

Handling and disposal of ashes in connection with the pulverized coal installation is a matter deserving very careful study and in which there is considerable room for improvement. While the sluice has been used with eminent success in many installations, the excessive formation of slag or clinker in other installations has presented problems which would be better handled by other methods.

With the forcing of boiler equipment to very high ratings, the problem of water treatment to prevent the formation of scale has become of primary importance. Many satisfactory systems have been evolved and are in general use and in addition the installation of evaporators for the central station has become standard practice. The use of deareators for the elimination of oxygen in the system is also standard in large stations, the presence of oxygen being the primary cause of corrosion and pitting. Even with deareators installed, some difficulty has been experienced with corrosion of boiler drums and tubes and the matter of its prevention is receiving considerable attention. The more or less general use of a protective coating applied to the interior of drums and tubes is being made, particularly in new boilers of large size.

While we have been discussing the trend in large central station practice, it is worthy of mention that the improvement in fuel burning equipment and furnace design and the introduction of the air preheater is making possible a heat balance in the medium and large size industrial plant which closely approaches the best practice in the largest modern central station.

In general, modern boiler room equipment and practice has met the demands of the prime mover manufacturers whose requirements have been higher steam pressures and temperatures for higher capacities and efficiencies, with greater continuity of service. It may be stated that while a few installations of boilers have been made at 1200 to 1400 lb. pressure, the anticipated practice in central station and industrial plants will be between 250 and 650 lb. pressure, with steam temperature around 750 deg.

Fuel Burning Methods Show Steady Progress

LARGER SIZES OF STOKERS, USING PREHEATED AIR, TURBULENT BURNERS FOR PULVERIZED COAL, IMPROVED DRYING METHODS, INCREASED USE OF UNIT MILL AND IMPROVEMENTS IN CENTRAL PREPARATION SYSTEM ARE OUTSTANDING FEATURES IN YEAR'S PROGRESS

AS POINTED OUT in our January 1, 1927 analysis, the principal developments at that time were the increasing use of the water cooled furnace wall, both for pulverized coal and stokers, the trend towards the unit pulverizer, and the turbulent burner. These trends are even more pronounced this year, with refinements and some other trends in addition. Few new principles have developed; it appears rather that the next two or three years will see a further consolidation of the ground already gained.

Among the latest developments are automatic zone controls for chain grate stokers and for individual tuyeres of underfeed stokers; another type of underfeed stoker is announced with separate air zones hand controlled by the operator. Stokers have continued to increase in size and use of preheated air and overfire air with them has become common. Stoker ash hoppers are deeper and use of clinker grinders has become almost standard practice. Spectacular accomplishments

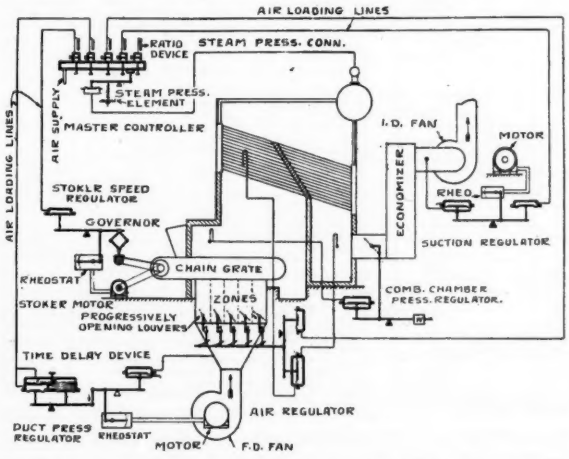


FIG. 1. COMBUSTION CONTROL FOR CHAIN GRATE STOKERS, AUTOMATICALLY REGULATING LENGTH OF FIRE AND PRESSURES AND AMOUNTS OF AIR IN INDIVIDUAL ZONES

are not possible with the stoker, of course, owing to the inherent nature of the combustion problem, but refinements of details are constantly raising its standard of performance and efficiency.

With increase of attention to the use of economizers and air preheaters, there is a tendency to consider the heat exchanges of the entire plant in the selection of the fuel burning equipment and also to select the steam generating and fuel burning equipment together. Increased use of water cooled walls has removed many of the limitations placed on the stoker by complete refractory furnaces and has made it possible to make better use of preheated air. This permits increased capacity and smaller furnaces and it is now felt that in most cases the only limitation for the stoker is the amount of fuel that can be burned in a given furnace, assuming a steam generating unit that can absorb the heat fast enough.

In the field of pulverized coal burning, one of the most important developments of the year has been the turbulent burner, designed to shorten flame travel and secure intimate mixture of fuel and combustion air. Several types of these were described in the November 15, 1927 issue of Power Plant Engineering. Another method of securing turbulence, employed with the steam generator and the larger well-type furnaces, is to use fan tail burners set on all four sides of the furnace,

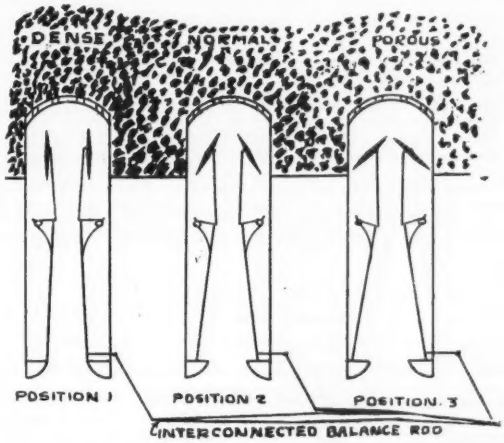


FIG. 2. AUTOMATIC CONTROL FOR VARYING PRESSURES AND AMOUNT OF AIR IN THE INDIVIDUAL TUYERES OF AN UNDERFEED STOKER. VARIATION IN AIR PRESSURE CAUSED BY VARIATIONS IN FIRE BED CAUSES MOVEMENT OF VANES BY DIFFERENTIAL PRESSURE. THIS MOVEMENT GIVES CORRESPONDING MOTION TO AIR DAMPERS IN TUYERE

their center lines tangential to a circle inside. This produces high turbulence and permits greatest use of the furnace volume.

There is still considerable controversy as to the relative merits of the unit mill system of pulverized coal preparation and the bin or central system. Each has its particular advantages and disadvantages and careful study should be made of each individual case in which they are to be applied. A significant development is the modified central system, as used at Morrell St., in which the flexibility of the central system is obtained without the use of a separate preparation house, the mills and auxiliaries being placed in the boiler house, with suitable conveyors for green coal and pulverized coal tying the whole system together. As an example of the simplicity of the unit system, Bayside station has two unit mills per boiler, with turbulent burners. There are no powdered coal conveyors, cyclone collectors or other preparation auxiliaries. The unit system will also be used at the new State Line plant to serve five 10,294-sq. ft. boilers. Each boiler will be served by two 20-t. mills, supplied with preheated air and the coal will be burned by turbulent burners in water cooled furnaces.

Coal handling methods have developed in some of

the details during the past year, but no new fundamental principles have come to light. Increased interest is shown in methods of taking coal samples automatically both for stoker-fired and pulverized coal fired plants.

More attention is now being given to ash handling methods because of the desirability in some cases of delivering the ash out of the boiler house in such a form that it can be used for concrete making and other construction purposes. Some stations even secure an appreciable revenue from the sale of their ash. Ash sluices are widely used; several stations have provision for dumping ash direct into railroad or industrial cars. Ash handling methods at the Charles R. Huntley station are important as they illustrate a method of handling some of the grades of fuel with low fusing ash. Here the bottom of the well type furnace has a refractory floor concaved at the sides. There is no water screen and the slag is allowed to form in a pool on this floor, the heat of the furnace keeping it molten. At suitable intervals it is run off, still molten, to a disintegrating box where it meets a jet of water; the sudden cooling effect shatters the slag into a granular product similar to coarse sand. This is sluiced to a sump, whence it is pumped for disposal.

Owing to the interest in removing fly ash from the flue gas, especially in pulverized coal plants, considerable new equipment for this purpose has been developed. Among the plants tabulated herewith, two industrials use blast furnace gas as the principal fuel. In both of these plants, the gas is cleaned before being burned in the furnace. Air for soot blowing is used at only one of the stations tabulated—Stanton—but its use here was dictated by the success of the method at Columbia Power Station.

It will probably be of interest to comment on the data shown by the tabulation in the light of the foregoing remarks. Figure 1 in the following article on Furnace Practice shows diagrammatic cross-sections of the various furnaces under discussion. Complete data on installations of the steam generator and of the well-type furnace were not available for this tabulation.

Types of Fuel Burned

Types of bituminous coal burned range from Iowa coal of 9100-B.t.u. per lb. at Des Moines, burned on chain grate stokers, to the West Virginia and Kentucky coals of about 14,000 B.t.u. used at Morrell St. and Kips Bay. Stanton burns anthracite culm from the nearby Pennsylvania fields. Lauderdale burns fuel oil. The Minnequa plant and the Massillon plant, both serving large steel mills, burn blast furnace gas with pulverized coal for standby and Massillon has one boiler equipped with a chain grate stoker to burn coke breeze. At Neches, a central station, natural gas with a heat content of about 950 B.t.u. per cu. ft. is the principal fuel, with pulverized coal and fuel oil for standby. At this plant the furnaces are designed and other provisions made for later use of pulverized coal. Three Rivers, serving a large paper mill, was designed to burn either Nova Scotia or Virginia and Pennsylvania slack.

Of the pulverized coal plants tabulated, all but one dry the coal to some extent before pulverizing, as part of the central preparation system they use. Morrell St. uses a modified central system employing stationary steam dryers through which the coal flows on its way to the mills. At Kips Bay a rotary steam heated dryer is used, while Lakeside uses this type and also the coal-fired rotary type. Other types used are the stationary steam dryer and the stationary vertical flue gas dryer. It will be noted that the steam dryer is used oftener here than in the plants tabulated last year. The rotary steam dryer is a recent development.

FUEL BURNING & PREPARATION EQUIPMENT

NAME OF STATION	FUEL				% MOIST.		PULVERIZING MILLS				BURNERS OR STOKERS			AIR SUPPLY						ASH DISPOSAL	
														PRIMARY			SECONDARY				
	B.T.U. + KIND	METHOD OF FIRING	PRE-PARATION	TYPE DRYER	INITIAL	FINAL	TYPE	CAPACITY + NO.	DRIVE + POWER CONSUMED	FIN'S OF PULV-200 MESH	TYPE + NO./B.L.R.	RATIO D'B.H.S TO GRT.	STOKER DRIVE	METHOD-COOLING WALLS	% OF TOTAL	WHERE INTRODUCED	TEMP	% OF TOTAL	WHERE INTRODUCED	TEMP	FURNACE	FLUE GAS
LAKESIDE [45]	W. VA. 12,800	P.C. SUSP.	CENTRAL PREP. PLANT	COAL FIRED + ROTARY STEAM	3.5 TO 10	1.5 TO 3	ROLLER IMPACT	20 TON PER HR.	MOTOR 18 KW-HR/TON	65%	12 VERT. FAN TAIL WITH DEFLECTORS FOR TURBULENCE			WATER + RAD. SUPERHTR.	15	BEFORE BURNERS 18 IN. H_2O	350	85	THRU. FRONT WALL 0.5 IN H_2O	650	STEAM JET CONVEYOR	WATER SPRAY IN BREECH'G
BAYSIDE	YOUGHIOGHENY 13,500	PULV. SUSP.	CRUSHER, BUNKER TO UNIT MILL	AIR TO MILL	6		UNIT	2-6,000 LB./HR.	CONSTANT SP. 50 CAGE MOTOR	80%	4 TURBULENT FORC. DRAFT		(NOT NO. P.)	WATER-FIN TUBES PROT. "		AT MILL	340		AT BURNERS	340	DUMP DIRECT TO INDUST. CAR	
STANTON	ANTH. CULM 10,500	CH. GR. STOKER	CRUSHING NOT NEEDED	NONE	12 14						1 CHAIN GRATE	31.2	D.C. MOTOR	AT THROAT ONLY		STOKER WINDBOX	380		FURNACE THROAT	500	SLUICE TO YD PIT-BUCKET TO CARS	SOOT HOPPERS SOOT RECIRC. TO FURNACE
EAST RIVER	POCAHONTAS 14,000	PULV. SUSP.	CRUSHER, CONVEYOR, SCALES TO BUNKER	GRID STEAM STAT.	7	3	TO SCREEN MILLS	6-15 TON PER HR.	MOTOR-22.5 HP PER TON	85%	10 VERT. FAN TAIL			WATER	15	FEEDERS 18 IN. H_2O	225	85	FRONT WALL BELOW BURN. 4 IN. H_2O	544	SLUICE	CYCLONE + WASHER TYPE COLLECTOR
MORRELL ST.	W. VA. BIT. 13,600	PULV. SUSP.	MODIFIED UNIT * CENTRAL	STEAM STATIONARY	4	1	ROLLER IMPACT	4-15 TON PER HR. EA.	A.C. MOTOR 50 CAGE	65%	10 VERT. F.D. FAN TAIL			WATER-FAB SUPERHEATER VENT. FRONT WALL	15	WITH COAL THRU. BURNER 10 IN. H_2O	235	65	THRU FRONT WALL 0.05 IN H_2O	235	DRAG CONV.	HOPPER TO ST. JET CONV.
DES MOINES	IOWA 9,100	CH. GR. STOKER	BREAKER, BUNKER, TO SCALES								CHAIN GRATE	34.0	BRUSH SHIFTING MOTOR	WATER-BACK + SIDE WALLS		STOKER AIR CHAMBER	180		OVER FIRE AIR THRU FRONT ARCH		HOPPERS TO RR CARS	
BUCK	COAL 15,000	P.C. IN SUSP.	CRUSHER, STORAGE, TO BUNKER	GRID STEAM STATIONARY	5		ROLLER IMPACT	4-15 TON PER HR. EA.	A.C. MOTOR	65%	19 VERT F. D. FAN TAIL			WATER		AFTER FEED 20 IN. H_2O	200		FRONT WALL 2.5 IN. H_2O	200	SLUICE	NO PROVISION
WHIPPANY	PA. ANTH. NO 3 BUCK W. 12,000	CHAIN GRATE STOKERS	CONV. TO BUNKERS								1-CHAIN GRATE	46.0	D.C. MOTOR	AIR		STOKER AIR CHAMBER	250		STOKER AIR CHAMBER	260	HOPPERS TO RR CAR	
LAUDERDALE	FUEL OIL 18,000 NAT. GAS 950	SUSP.	STORAGE, HEATERS TO BURNERS								19-MECH. ATOMIZING			WATER		AT BURNERS	485		AT BURNERS	485		
HARBOR POINT	COAL 14,000	U-FEED STOKERS	STORAGE, CRUSHER, BUNKER TO W. LARRY								1-IH RETORT UNDERFEED	60.0	D.C. MOTOR	WATER		UNDER STOKER	RM TEMP		UNDER STOKER		SLUICE	CINDER HOPPERS UNDER STACKS
NECHES †	FUEL OIL 18,000 NAT. GAS 950	SUSP.	OIL STORAGE TO HEATERS TO BURNERS								11 COMB. GAS + OIL					AT BURNERS	ROOM TEMP.		AT BURNERS	ROOM TEMP.		
KIPS BAY	W. VA. AND SPOT MARKET 14,500	PULV. SUSP.	BY WATER CRUSHER TO BUNKER 12 CENT. PREP. PLANT	VERT. POT STEAM HEATED GRIDS	1.5-7.5	1		5-15 TON PER HR.	MOTOR	50% 60%	12 VERT. FAN TAIL			WATER		AT BURNERS 10-16 IN. H_2O	150 TO 200		HOLLOW FRONT WALL 6.3 IN. H_2O	450	SLUICE	CINDER CATCHERS TO TRUCKS
BEACON ST.	W. VA. KY. S. OHIO 13,5000	U-FEED STOKERS	CRUSHED AT COALING STA. MONORAIL TO BUNKERS								12-14 RETORT INCLINED	61.1	MOTOR	PART AIR-COOLED		STOKER AIR CHAMBER	70		STOKER AIR CHAMBER	70	HOPPERS TO TRUCKS	
MINNEQUA	COLO. SLACK 12000 B.T.U. GAS 90 B.T.U. CU. FT.	SUSP.	CENT. SYS-COTTRELL PRECIPITA	ROTARY DIRECT FIRED	2 TO 5	2	ROTARY BALL SCREEN	12000 LB/HR. EA.	MOTOR 47 KW. H./T. TOTAL FOR PREP.	85%	8 V FAN TAIL 4 HOR. ASP FOR GAS			NONE	20	WITH PULV. COAL	ROOM TEMP.	80	AIR DOORS IN FRONT OF SETTING	ROOM TEMP.	AUTO. SKIP-HOIST TO BINS	INDUSTRIAL CAR
MASSILLON	B.F. GAS) COAL) COKE —	SUSP.) CH. GR. STOKER	UNIT SYST. FOR P.C. - CRUSHER TO BUNKER	AIR ADMIT TO MILL	6	2.5	UNIT-IMPACT	8-4500 LB/HR. EA.	6 BY MOTOR 2 BY TURB. 10-12 KW HR/T.	35%	ON 5 BOIL. 4 VERT FT-PC ENGR-GAS 1 CH. GR. STOKER	31.5	ENGINE OR MOTOR	AIR-WATER SCREEN		THRU WALL TO FEEDER	300 TO 350		THRU PORTS IN FURNACE WALL	ROOM	HOPPERS TO DUMP CAR	
THREE RIVERS	NOVA SCO. VA + PA. SLACK	P.C. IN SUSP.	CENT. PREP. SYS-SEP. BLDG. COAL PUMPED 600 TO B.L.H.	VERT. GRAVITY - GRID	DATA NOT AVAILABLE		5 ROLL IMPACT AIR SEP.	5-12,000 LB/HR. EA.	MOTOR		6 VERT. F.D. FAN TAIL			WATER SCREEN AIR		AT FEEDER 20 IN. H_2O	100		AT BURNERS 3 IN. H_2O	425		

Δ - THESE DATA ARE FOR THE INDOOR BOILER ONLY. IN ADDITION THERE ARE 16 P.C. FURNACES SERVING A TOTAL OF ABOUT 25,000 B.HR. NORMALLY OPERATING AT 250% OF RATING.
* - MILLS IN BASEMENT BETWEEN BOILERS, BINS, COLLECTORS AND CYCLONES ABOVE; CONVEYORS ACROSS P.C. BUNKERS.
† - NATURAL GAS IS MAIN FUEL, WITH OIL FOR STANDBY. PROVISION FOR PULV. COAL IN FUTURE.

Air is admitted to the unit pulverizing mills at Massillon and at Bayside, illustrating the growing tendency in this respect. It has been found that this may sometime increase the power consumption of the mill somewhat, but with the unit mill system it obviates the necessity for separate dryers. It has also been found that with preheated air to the mill, the total capacity of the mill may be increased and this is sometimes of value even with increased power per ton. Finally, admission of air to the mill increases ease of handling the pulverized coal.

Most of the plants tabulated here use the central system of preparation. Morrell St. illustrates a tendency in the use of this system that promises to prove valuable. This modification of the system, by eliminating the separate preparation house, is intended to combine the advantages of the bin and unit systems. Bayside is an example of the growing tendency toward the unit mill.

Drying Practice for Pulverized Coal

In the pulverized coal plant, the moisture in the coal, both surface and inherent, is a factor of greater

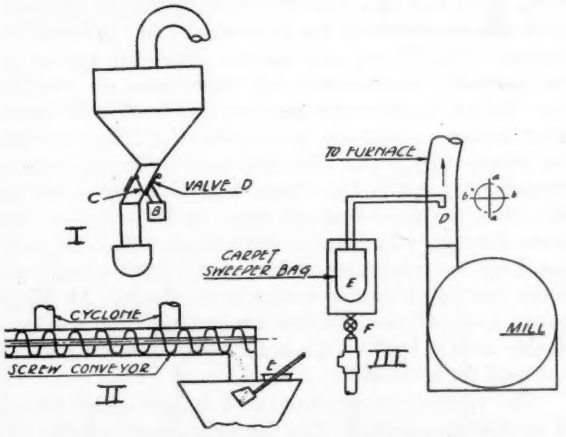


FIG. 3. I AND II—METHODS OF SAMPLING PULVERIZED COAL FROM STORAGE SYSTEM. III—METHOD OF OBTAINING SAMPLE FROM UNIT MILL SYSTEM

importance than in the stoker-fired plant. Initial moisture in the coal delivered to the former, in the tabulation ranges all the way from 1.5 to 10 per cent with the average about 5 per cent. This is usually dried to between 1 and 3 per cent, and this seems to be an average figure for plants using these varieties of coal. With lignite and other fuels the drying will be materially different. It is believed that the surface moisture has a greater influence than the inherent on the workability of the coal in the mill.

Pulverizing mills of 15 t. or 20 t. capacity, as noted in the table, are used in most of the plants having a central preparation system, while the capacity of the unit mills employed depends on the amount of coal to be fired in the furnaces. In many central stations, mills are motor driven, since the extraction feed water cycle most commonly used is usually accompanied by electric drive for all possible plant auxiliaries. With certain heat balance arrangements, however, one or more of the mills may be turbine driven, as at Massillon.

Average fineness of pulverization is difficult to determine but from the figures available it seems to be about 65 to 70 per cent through a 200 mesh screen. At Bayside, East River and Minnequa, this figure is 80 to 85 per cent, while at Massillon, burning pulverized coal and blast furnace gas together, it is 35 per cent. Figure 3 shows two methods of obtaining pulverized coal samples for fineness and other determinations. Considerable attention has been given to the methods of obtaining samples.

With most central systems, the fan tail burner is used, as tabulated, especially where secondary air is introduced through any part of the furnace wall. This type of burner can be modified with deflectors to produce some turbulence, as at Lakeside and in some cases a forced draft type can be used to supply the required amount of secondary air under pressure at the burner. Other types of burners definitely designed to produce turbulence, such as those at Bayside, are designed so that an entering stream of pulverized coal and carrying or primary air (sometimes preheated) meets the secondary air in the burner; one or both of the streams is given a swirling motion by some part of the burner and the resulting flame swirls as it burns. With such burners, all the combustion air usually enters at the burner.

With the fan tail burner, about 15 per cent of the total combustion air is introduced at the feeder, the remainder entering through the walls as secondary air. With turbulent burners, these proportions will vary, depending on the flame conditions. Combination burners for oil, gas and pulverized coal have been developed to burn all three at once or any combination desired. Neches uses a combination oil and gas burner and provision has been made for future use of pulverized coal. At Lauderdale, fuel oil is burned with a mechanical atomizing type of burner, while at Minnequa and Massillon fan tail burners set in the top furnace arch feed the pulverized coal and special horizontal aspirating types feed the blast furnace gas.

Fire Loss Should Be Reduced

We shudder to think that once the custom of burning people at the stake was considered respectable but, in the very modern year of 1926, 10,000 people, in the United States alone, lost their lives by fire, which is a reduction of some 34 per cent from 3 yr. before.

Average fire loss last year in 377 American cities was $3.35 per capita, which every property owner helps pay in insurance, for insurance is merely a method of distributing the loss. Average fire loss for British cities was about $1 per capita and, for the European continent, a half to one-tenth that. Yet America has the best equipped fire departments in the world.

Fire loss is not, like the weather, something that we must passively endure. We can do something to reduce this loss and save human lives. Carelessness is the chief cause of fires. We can train ourselves, our families and our employes to be careful with fire—with matches, cigarette butts, oily waste, stoves, ashes and open lights. Then it is our duty to provide extinguishers or sprinklers. The first three minutes is the critical time in every fire. To have a fire is not only a misfortune; it is a disgrace!

Furnace Design and Performance Improves

INCREASING USE OF WATER-COOLED WALL, EITHER TOTAL OR PARTIAL, WITH PULVERIZED COAL, OIL, GAS AND STOKER-FIRED FURNACES LEADS TO HIGHER COMBUSTION RATES, AIDED BY PREHEATED AIR AND OTHER REFINEMENTS IN DETAILS

REFINEMENTS in pulverized fuel equipment point toward a definite decline in furnace size for a given amount of heat liberation. In many of the furnaces put in operation in 1926, the average ratio of cubic feet of furnace volume to square feet of boiler heating surface was about 0.75, while the average heat liberation seldom exceeded 10,000 or 12,000 B.t.u. per cu. ft. per hr. The furnaces tabulated herewith for pulverized coal have an average furnace ratio to heating surface of about 0.85 (the highest being 1.44) but heat liberation in most cases averages about 20,000 B.t.u. per cu. ft. per hr. at corresponding boiler ratings of anywhere between 300 and 500 per cent. In the new Fordson steam generator unit the heat liberation at 600 per cent of rating is about 34,000 B.t.u. per cu. ft. per hr. It is evident that the above figures represent a material decrease in furnace volume for a given energy liberation.

Adaptation of the water-cooled wall, together with refinements in stoker design and operation, have reduced furnace maintenance with stokers, increased their capacity and led to operation at high efficiency and high ratings. Boiler ratings as high as 600 or 700 per cent have been attained with stokers and heat liberation rates of 40,000 B.t.u. per cu. ft. per hr. and upward are not uncommon under special conditions. The average heat liberation rates, however, at boiler ratings of 300-400 per cent, are between 25,000 and 30,000 B.t.u., a little higher than the average for pulverized coal furnaces.

Increasing application of the water-cooled furnace has led to the steam generator, consisting principally of a water-cooled furnace in which most of the steam is generated in the furnace walls. Several installations of this generator have been made and are working out successfully, although complete operating data are not yet available. Some of these have been in industrial plants and some in central stations. Other types of complete water-cooled furnaces have been designed, notably the well type furnace. This type, installed at the Charles R. Huntley station, has been successfully operated at rates of as high as 60,000 B.t.u. per cu. ft. per hr. Another interesting development is in the use of a small well type or vortex furnace designed to adapt an ordinary h.r.t. boiler to pulverized coal with no change in the setting.

Some data were recently obtained from tests conducted with pulverized coal in a Scotch marine boiler. In these tests an average of 60,000 B.t.u. per cu. ft. of furnace volume per hour were liberated during the last 48-hr. period of the test. This was figured on the basis of the entire combustion space, which in a Scotch boiler includes more than the furnace proper. If only the primary combustion space were considered, it is stated that the heat liberation would be about 140,000 B.t.u. This high value was obtained in large measure, it is stated, by flame turbulence and high percentage of superfines in the pulverized coal. The test was run to determine the feasibility of burning pulverized coal in the limited Scotch boiler furnace, for marine use.

It is of interest to note that the heat liberation at Lakeside is 10,000 B.t.u. per cu. ft. per hr., much lower than the other pulverized coal furnaces. As a matter of fact, the designers did not consider this factor to any great extent, since they were not trying to reduce furnace volume, but were more interested in other factors of the furnace design, such as maintenance.

USE OF WATER-COOLED WALLS

Although use of the water-cooled furnace wall is increasing rapidly and many installations have been made of totally water-cooled furnaces, at the same time many other installations have been made in which only a part of the wall is water-cooled, the remainder being air-cooled or solid refractory. The totally air-cooled wall is still being installed and is giving excellent service, as at Columbia and Avon, noted last year. Figure 1 shows the various types of walls in the plants tabulated here. Kips Bay and East River are typical of the complete water-cooled wall for pulverized coal. Morrell St., Neches, Three Rivers and Harbor Point are typical of the partially water-cooled wall with some air cooling. Des Moines typifies the water-cooled wall with chain grate stokers. Lakeside is considerably different from the others. Here the side and rear walls are radiant superheaters, while the front wall is water-cooled by fin tubes, the fins being cut away at intervals to form ports through which air is introduced. This air, coming from the preheater at the rear, passes around the boiler through a double casing to the front. At Whippany, also, air is circulated around the furnace by a double casing, but this air is for ventilation only and is not used for combustion.

The furnace at Stanton, with its air-cooled throat, is of special interest. This burns anthracite culm and the air admission at the throat produces a Bunsen burner effect. At Whippany, for burning No. 3 buckwheat, a similar furnace is used, except that air is not admitted at the throat. Water-cooled arches have been used with success in several chain grate stoker installations. Des Moines is typical of the water-cooled wall used with chain grate stokers while the present extensions at Saginaw River, Edgar, Norfolk and others not tabulated are typical of the water-cooled wall used with underfeed stokers.

AIR SUPPLY TO THE VARIOUS FURNACES

Temperatures of primary air admitted with pulverized coal, as shown by the table, range from 200 at Kips Bay to 350 at Lakeside and Massillon. For the fuel oil burners at Lauderdale, all air is admitted to the burners at 485 deg., while at Neches it is at room temperature, provision being made for future air preheaters. Secondary air may be at a higher temperature, 400-600 deg., as at Lakeside, East River and Kips Bay. In some cases, however, as at Morrell St., it is the same. At Bayside, all air enters at the burner, being taken direct from the air preheater.

With stokers using preheated air, the air temperature is seldom over 400 deg. under present practice,

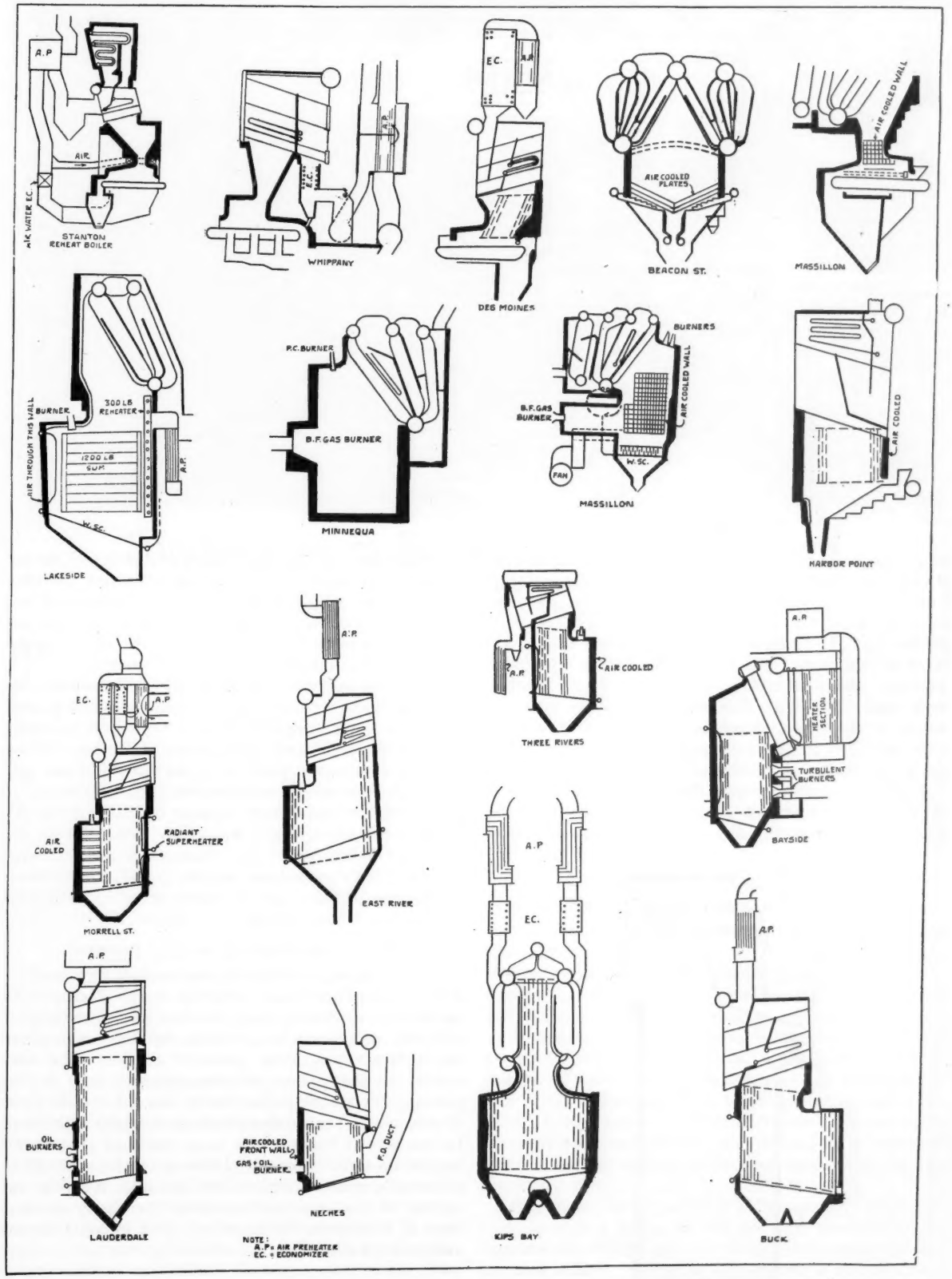


FIG. 1. DIAGRAMS OF REPRESENTATIVE BOILER AND FURNACE INSTALLATIONS, SHOWING LOCATION OF AIR PREHEATERS AND ECONOMIZERS, WATER-COOLED WALLS AND HEARTH SCREENS, BURNERS AND STOKERS

FURNACE AND DRAFT PRACTICE

NAME OF STATION	FUEL: KIND & B.T.U. AVE.	FUEL: METHOD OF FIRING	FURN. VOL. CU.FT. PER SQ.FT. B.H.S.	HEAT LIBERATED B.T.U. PER CU.FT./HR.	CORRESPONDING BOILER RATING	AIR PREHTR. TYPE + SURF. SQ.FT.	ARE ECON. INSTALLED	FURNACE WALLS: TYPE	FURNACE WALLS: W. WALL SURF. SQ.FT. PER BOILER	FURNACE WALLS: HEARTH SCREEN SURF. SQ.FT.	FANS: CAP'EA: C.F.M.* @/BLR F.D.	FANS: CAP'EA: C.F.M.* @/BLR I.D.	FANS: DRIVE F.D.	FANS: DRIVE I.D.	FANS: SPEED-R.P.M. F.D.	FANS: SPEED-R.P.M. I.D.	FANS: STAT. PR. IN. H_2O F.D.	FANS: STAT. PR. IN. H_2O I.D.	CHIMNEY HEIGHT + NO. BOILERS PER STACK
LAKESIDE △	W.VA. 12,800	PC. SUSPENS.	1.05	10,500	300%	PLATE □ 67,300	NO	FRONT WALL-FIN TUBES 2 SIDE W.-1200 SUPERHTR. REAR W.-300 REHEATER	1010 432 432	534	2 † 42,000	2 77,500	MOTOR		850	575	3.5	6.5	+ 200
BAYSIDE	YOUGHIOGH. 13,500	P.C.	0.81	ABOUT 20,000	150,000 LB/HR. 550%	ROTARY ELEM. 110,000 LB/HR.	HEATER SEC. IN BOILER	NO.1-FIN TUBES NO.2 PROTECTED TUBE	1705 1214	NONE	2 ○ 110,000 LB/HR.	2 ○	1 MOTOR AIR PREHTR. EL.+ 2 INTEG. FANS	DRIVES FANS	VARIABLE MAX.	1800	4.2		2 100
STANTON	ANTH. CULM 10,500	CH. GRAT. STOKERS	0.434	NOT AVAILABLE		ROTARY EL. 40,500	YES AIR-WATER	— STANDARD AIR COOLED	REFRACTORY — THRU	AT	2 ○ 33,000	2 ○ 56,000	1 MOTOR A.P. ELEMENT & 2 FANS		VARIABLE		6.7	3.3	+ 150 FT.
EAST RIVER	POCAHONTAS 14,000	P.C. IN SUSP.	1.075	19,000	500	STA. PLATE 28,900	NO	FIN TUBE WATER COOLED	3574	560	1 □ 60,000	1 150,000	STEAM TURB. THROUGH REDUCING GEAR		1100	560	6.4	8.5	6 376.5
MORRELL ST.	W.VA. BIT. 13,800	P.C. SUSP.	1.44	14,000	300	PLATE 10,980	YES ST. TUBES LEAD COATED	RAD. SUPERHTR. FIN TUBES VENT. FRONT WALL	219 976	483	1 54,000	1-260,000 LB/HR.	VARIABLE SPEED D.C. MOT.	VAR. SPD. D.C. MOT. + AC MOT.			3	5.25	2 70 FT.
DES MOINES	IOWA 9,100	CHAIN GRATE	0.41	NOT AVAILABLE		PLATE 12,420	YES	FIN TUBES WATER COOLED SIDE WALLS	310	NONE	1 78,000	1 113,000	SLIP RING DRUM CONT. MOTOR	SYN. SPEED MOTOR			4.5	6.0	3 NOW 4 ULTIMATE 75' ABOVE ROOF
BUCK	COAL 13,000	SUSP.	1.07	"	"	PLATE 232 ELEMENTS	NO	FIN TUBE WATER COOLED	2585	NOT AVAILABLE	2 * 32,500	2 70,800	MOTOR		VARIABLE		2.5	3.5	2 77
WHIPPANY	PA. ANTHR. + 3 BUCKWHT 12,000	CHAIN GRATE	0.203	"	"	PLATE 6170	YES	REFRACTORY AIR COOLED			1 45,000	1 59,000	SLIP RING MOTOR		1155	1160	6.0	5.5	3 TO 1 2 TO 1 70 FT.
LAUDERDALE ◇	FUEL OIL		0.896			ROT. EL. 82,000	NO	FIN TUBES WATER COOLED	2824	338	1 ○	1 2 ○ 304,000 LB/HR.	MOTOR		600 TO 1200	450 TO 900	9.53	6.5	2 85' ABOVE ROOF
HARBOR POINT	COAL 14,000	U-FEED STOKERS	0.425	20,200	200	NONE	NO	F. TUBE SIDE-WATER BACK IN BRIDGE W. AIR COOLED FRONT	500		1 120,000	1 278,000	2 TURB. 1 MOTOR	TURB.	VARIABLE		7.0	4.6	2
NECHES ⓓ	N.GAS 950/CU.FT. FUEL OIL 18,000/LB.	SUSP.	0.526			FUTURE	NO	PROTECTED WATER TUBES AIR COOLED FRONT WALL	1440	PROT. TUB. FORM FLOOR SEE DIAG.	2 30,000	FUTURE	SLIP REG. MOTOR				6	NONE	2-200' ABOVE BOILER RM. FL.
KIPS BAY	W.VA. AND SPOT MARKET 14,500		1.3	22,000	325,000 TO 450,000 LB./HR.	PLATE 50,000	YES	WATER COOLED-FIN TUBES	2944	688	PRI. SEC. 20,000 90,000 2-110,000		WOUND ROTOR MOTORS REMOTE CONTROL		PRI. SEC. 400-800 600-1200 800-1600 1200-1800 1600-2400 2-200-900		PRI. SEC. 10-16 IN. 6-6.5 IN. 2-15.5 IN.	6-12 IN. 2-ER. 5 IN.	
BEACON ST.	W.VA. KY + S. OHIO 13,500	U-FEED STOKERS	0.40				NO	NONE			1-50,000 TO 155,000	1-100,000 TO 325,000	D.C. MOTOR		217 TO 645	81 TO 325	6.0	6.0	3 126 FT.
MINNEQUA †	COLD. SLACK 12,000 B.F. GAS 94	SUSP.	0.8		NORMAL 150-200 MAX. 300	NONE	NO	REFRACTORY			1 FORT BD. 25,000 EA. FOR PRI. AIR	1 110,000		VAR. SPD. D.C. MOT.			6 IN PRI. AIR	1.5	1 40' FROM FANS
MASSILLON ●	B.F. GAS } COAL } COKE	SUSP. STOKERS	0.73	14,000 MAX.	325 MAX.	BOILER SIDE WALLS	INTEGRAL WITH BOILERS	AIR COOLED WITH WATER SCREEN		235	27,000	1 FOR 580. 60,000	TURB.	MOTOR + TURB.	1170	1170	4.5	7.0	6 365
THREE RIVERS	NOVA SC. VA. + PAL. SLASK.	P.C. IN SUSP.	0.80		300 MAX.	PLATE 6363	NO	FIN TUBE W. COOLED AIR COOLED FRONT WALL	1201		1 35,000	1 88,000	2 SPEED MOTORS				2.5	3	? 200 ? FT.

△-THESE DATA ARE FOR THE 1900-LB. BOILER ONLY. IN ADDITION THERE ARE 16 P.C. FURNACES SERVING A TOTAL OF ABOUT 25,000 B.HP. NORMALLY OPERATING AT 250% OF RATING.
●-9 BOILERS EQUIPPED FOR B.F. GAS AND PULV. COAL. ONE BOILER HAS CHAIN GRATE STOKER FOR COKE. ELECTRIC DAMPER CONTROL AND COMBINED CONT. ON ALL.
†-BLAST FURNACE GAS IS MAIN FUEL. PULV. COAL IS FOR STANDBY - ALL BOILERS EQUIPPED FOR BOTH.
ⓓ-NATURAL GAS IS MAIN FUEL; OIL IS STANDBY. PROVISION FOR PULVERIZED COAL.
□-ALSO 1 PRIMARY AIR FAN - 24,000 C.F.M. - 18 IN. H_2O, FOR 2 BOILERS.
B-INSULATED CASING AROUND BOILER SETTING BRINGS AIR FROM PREHEATER AT REAR. AIR ADMITTED THROUGH FRONT WALL PORTS.
F.D. + I.D. FANS INTEGRAL WITH ROTARY ELEMENT AIR PREHEATER. ELECTRIC DAMPER CONTROL AIDS DRAFT REGULATION
○-WITH PROVISION FOR PULVERIZED COAL.
*-ALSO PRI. AIR FAN EACH 12,000 C.F.M. AT 20 IN. H_2O TAKING PREHEATED AIR FROM DUCT.
+-ALSO 12,000 C.F.M. PRIMARY AIR FANS, 18 IN. H_2O.

while the average figure seems to be about 300 deg. Mechanical considerations seem to be the determining factor of this limiting temperature. Stokers are now being designed for use with air preheated to as high as 600 deg. At Stanton, the air preheaters supply air at about 525 deg. This air, on its way to the stoker windbox, passes through an economizer, which tempers it to about 380 deg. The flow of economizer water, which is boiler feed water, is regulated or by-passed when necessary to keep a constant temperature of stoker air as the boiler output varies.

Cinders and fly ash from flue gas are removed in a variety of ways. At Lakeside a washer is installed in the breeching. East River has cyclone collectors and washer type collectors and Kips Bay is also provided with cinder catchers. At Stanton, cinders and unburned particles are caught by a hopper just behind the boilers and are returned by a screw conveyor to the rear of the combustion chamber to be completely burned, the ash dropping thence direct to the ash pit.

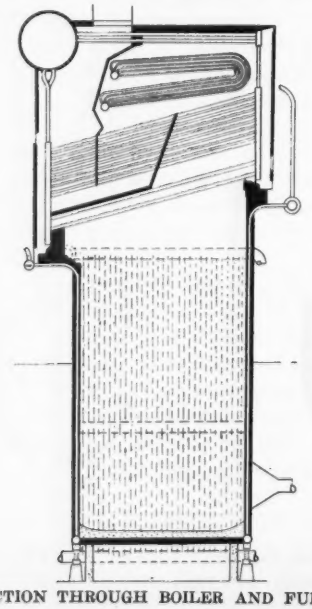


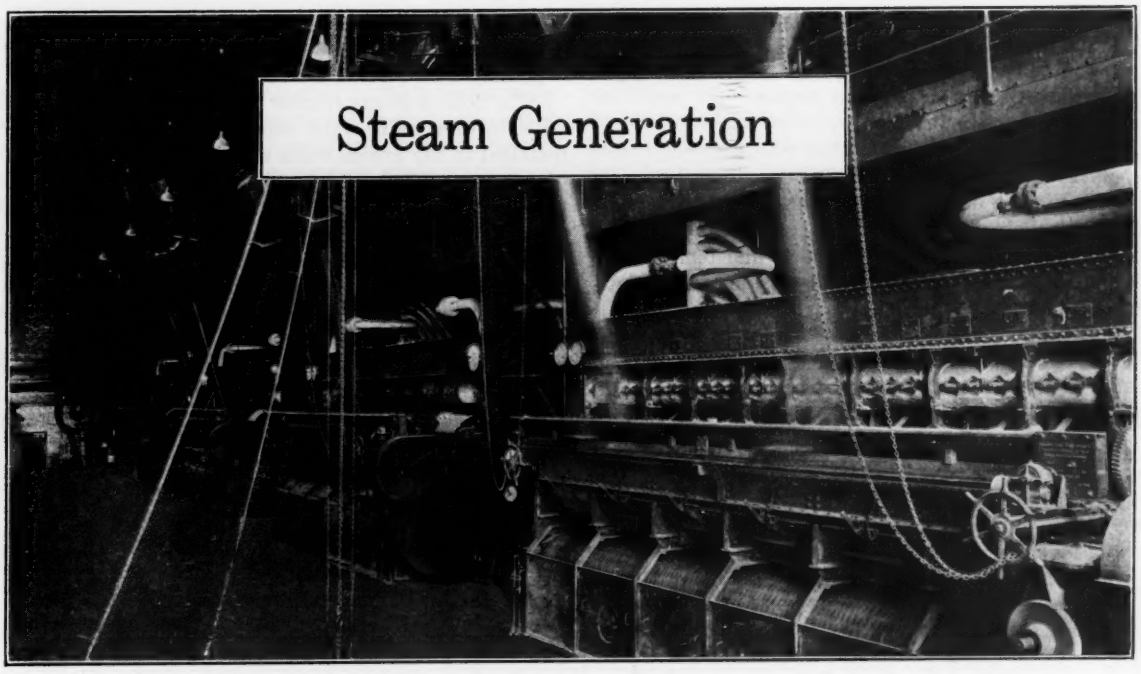
FIG. 2. SECTION THROUGH BOILER AND FURNACE AT CHARLES R. HUNTLEY STATION

Use of air preheaters is increasing, as is indicated by the table, both in central stations and industrial plants. Of the 16 plants analyzed, 11 have preheaters and provision is made for their installation at Neches. Three Rivers, an industrial plant, is typical of this class, and many other industrial installations have been made of plate, tubular and rotary element types. Of the 11 plants using preheaters, 3 use rotary element type, the remainder being plate type. In some central stations, the use of both economizer and air preheater is dictated by the heat balance and by their effect in stabilizing efficiency at higher ratings.

Some Considerations of Fan Practice

One of the interesting developments in fan practice is the arrangement used with the rotary element type air preheater. In this unit the fans are built integral with the preheater, being driven by the same motor that drives the rotating preheater element. For this reason, the fan speeds and preheater speed vary in proportion. To secure proper draft, therefore, some form of accurate and rapid damper control is used with them. In the case of Stanton this is an electrical control, remotely operated from the boiler control panel, while at Bayside a mechanical control is used. With the exception of the three stations using the rotary element type of preheater, the others all have separate forced and induced draft fans.

Eleven million added horsepower capacity, 40,000 mi. of new transmission line and 10 million new customers is the record of the last 7 yr. advance in electric system development.



Tendencies in Boiler Plant Operation

LARGER UNITS, HIGHER PRESSURES, HIGHER OPERATING RATINGS AND SOMEWHAT HIGHER STEAM TEMPERATURES ARE TRENDS IN BOILER OPERATION

ALTHOUGH it is becoming increasingly difficult to consider one of the two functions of a boiler without encroaching upon the other, we will attempt to confine ourselves to the heat transference function of what might better be termed the steam generator, leaving the heat generating function to be discussed under the section on furnace practice. Water walls, for example, were originally applied as a furnace protection but today consideration is given to them principally because of the added surface for steam making. Evaporation of water per sq. ft. of surface of water wall tubes is far in excess of that of any of the boiler heating surface with the exception of the rows of tubes immediately exposed to the furnace.

TREND IN SIZE AND CAPACITY INCREASING

Trends of boiler development are toward larger capacity units, higher pressures, higher operating ratings and somewhat higher steam temperatures. Operating experience with high pressure equipment has thus far been remarkably satisfactory where proper care is exercised in the design, selection and inspection of the material used for this purpose. Manufacturers are ready to offer superheaters to furnish steam at a maximum of 900 deg. F.

Changes in the designs of standard type boilers, so far as boiler tubes and baffling is concerned, have not been great. The principal advances have been in the extensive use of water walls and water screens in connection with air preheaters and a fuller use of economizers. Huge proportions, however, now exist. The boilers in the Beacon Station are of 4000 hp. capacity. One of these boilers has a heating surface of 42,370 sq. ft. The 1926 boiler unit at the Lakeside Station is 2 1/10 times larger than the 1920 unit. The steam output per boiler unit is 3 3/10 times greater than in 1920. The water content of these boilers has been limited to 40 per cent of their 1920 value when figured on the basis of equal boiler horsepower and the evaporation of a boiler full of water occurred 3 8/10 times more rapidly than in 1920 unit. The number of tubes in the new Lakeside boiler is 1602, as compared with 563 and 638 in the 1920 boilers. A steam pressure of 1405 lb. is carried in the Lakeside high pressure boiler. Two 1400-lb. pressure boilers are being installed in the North East Station of the Kansas City Power & Light Co.

SAVINGS DUE TO MODERN CHANGES ARE CONSIDERABLE

Savings experienced at the Calumet Station of the Commonwealth Edison Co. show over 5 per cent gain due to increase of steam pressure, 2½ per cent due to increase in temperature, 5½ per cent due to preheating and 2½ per cent due to additional preheating.

In the development of the so-called combustion steam generator, radical changes exist, particularly in the reduction of convection heating surface and the substitution of radiant action. This steam generator makes use to the fullest extent, of modern trends; furnace walls are completely water-cooled, pulverized fuel is employed and intense turbulence of furnace gases exists in the steam generator.

Boilers are now operating at increasingly high ratings, as high a rating as 700 per cent prevailing. At Saginaw the boilers are operating continuously at 600 per cent rating. Maximum evaporation is now obtained for short periods of time at rates nearly twice that of a year ago. The number of passes in the boiler have not changed radically in the past year although there is a

tendency to reduction in number rather than to increase. Of the plants investigated it will be seen from the table that the number of passes now range from one to four; most of the boilers having three passes.

Materials of Construction Are Present Limiting Factors

There is some doubt as to whether the metals which are now available will withstand the combined effects of stresses incidental to high pressures and temperature of 900 deg. F. for extended periods of time without excessive failures; however, the parts subjected to this extremely high temperature are few in number and relatively small in extent. For pressures of about 650 lb. and upward, the riveted construction is not considered advisable and other methods of making pressure parts are being evolved. The principal one so far is the forged seamless cylinder having heads integral with the shell. Such parts may be made without the use of riveting of any sort; the head, nozzle, etc., all being welded on. The boilers installed at Kearny station of the Public Service Electric & Gas Co. have headers that were cast from electric furnace steel. Forged steel sectional heads are also used in other boilers in high pressure drum construction.

All of the boilers investigated were fitted with cross drums. A unique feature of the boiler construction of the East River Station is the covering for the water wall, the usual refractory walls being eliminated. Two inches of diatomateous earth is placed next to the fins and fills the spaces between the tubes. Outside of this material is placed four inches of cement reinforced with one-eighth inch rods. The upper wall is covered with insulating material and a steel casing. The roof is built up of two and half inch tile laid on iron which rests on the horizontal circulating tube, together with two and a half inch insulating material, two and a half inches of ganistre and a half inch of cement. The drum is covered with 2½ in. of magnesia with steel plate over that.

The boilers of the Harbor Point station are equipped with fin tube water walls and cast iron water backs are installed in the bridge walls which add about 500 sq. ft. of heating surface. The main and auxiliary steam fixtures of the Neches Plant are designed for 400 lb. pressure using Sargo welded joints.

The principal features of the design of the boiler units of the Kips Bay Plant are, first, the proportions of the various parts of the absorbing surface and, second, the complete water cooling of the furnaces. In proportioning the heating surface, four general factors were of influence, namely, the effect of a large economizer on efficiency over a wide range of load, the air temperature believed to be necessary for smokeless combustion with high volatile fuel, the effect on investment cost of the elimination of as much of the less active surface of each type as was practicable and the ability to alter loads quickly which seemed desirable in an inter-connected system. Steam is generated at this plant at 275 lb. pressure although it is used for heating. Reduction being made by reducing valves to from 120 to 180 lb. depending upon the amount of steam transmitted.

In the boilers of the Des Moines Plant, the two lower rows of tubes are staggered to cool the ash below the slagging temperature before striking the upper tubes, which is the tendency in boiler plant operation.

Water Walls Add Much to Performance

Water walls not only permit of higher boiler ratings, but also avoid slagging troubles so prevalent otherwise in high pressure boilers. The popularity the water wall construction has attained may readily be seen by consulting the table. In the Neches plant, both side and

BOILER DATA

NAME OF STATION	NO. OF MAIN BLRS.	BOILER H.S. SQ. FT.	WATER SCREEN SURF. SQ. FT.	ABS. PRES.	NO. OF PASS'S	FURNACE VOL. CU. FT.	FURNACE VOL. CU. FT PER SQ. FT. W.H.S.	FUEL	F.W. CONTROL METHOD	F.W. CONTROL NO. PER BLR	SOOT BLOWG METHOD	TUBES NO. EL PER BOILER	TUBES WIDE	TUBES HIGH OR DEEP	DRUMS NO.	DRUMS STEAM DIA. INCH.	DRUMS STEAM LENG TH	SUPERHEATERS TYPE	SUPERHEATERS HEATING SURF PER BOILER SQ. FT.	SUPERHEATERS HEATING SURF PER BOILER % B.H.S.	SUPERHEATERS ELEMENTS DIA. INCH.	SUPERHEATERS ELEMENTS B.W.G. NO.	SUPERHEATERS TEMP° SUPER HEAT°	SUPERHEATERS TEMP° TOTAL	CORRESP'G BOILER RATING%
LAKESIDE *	1	26,532	1534 △	1405	4	30,100	1.05	BITUMINOUS PULV. COAL-W. VA.	M	2	MECH. STEAM	5	70	20	3	40	41'-0"	R	931.5 / 835	3.06 / 2.75			255 / 320	735 / 720	250 / 260
BAYSIDE	2	13,010 ‡	#1-1705 #2-1214	350	1	10,700	0.81	PULV. BIT. YOUGHIOGHENY	A	1	AUTO-MATIC				10			C	4100	31.5	1.5		318	700	350
STANTON	6	17,962		625	2	7,790	0.434	ANTHRACITE CULM	A	1	MECH. AIR	28			1	48	33'-11½"	C	2800	15.6	1⅞	10	238	700	175,000 LB/HR.
EAST RIVER	6	14,809 3574 †	560	390	3	20,857	1.075	PULV. BIT. POCAHONTAS	A	2	MECH. STEAM		54	16	1	54	29'-0"	C	3430	23			257	700	
MORRELL ST.	6	9571	1459 ‡	400	3	13,800	1.44	PULV. BIT. W. VA.	A	1	MANUAL STEAM	16	32	12		54	24'-8½"	1-C 1-R	3420	36.0	2	9	285	730	300
DES MOINES	5	15018	310 †	400	3	6183	0.41	BITUMINOUS SO. IOWA	A	1	MECH.	20	41 45	17 20	1	54	33'-0"	C	2900	19.0	2 1¼		250	695	250
BUCK	4	26,601	2585 †	440	3	2860	1.075	BITUMINOUS PULV. COAL	A	2	MECH. STEAM	24	51	18	1	54	34'-2½"	C					280	720	325
WHIPPANY	5	9,160		340	2	1859	2.17	ANTHRACITE NO. 3 BUCKWHEAT	A	1	STEAM	7	26	20	1	54	15'-0	C	1881	20.5	2	11	248	671	300
LAUDERDALE	3	17,440	3167 △	465	3	15,600	0.896	FUEL OIL	A	2	MECH.	22	58	19	1	54	34'-0"	C	4137	23.6			280	700	
HARBOR POINT	4	16,100	500 †	315	3	6850	2.35	COAL	A	2	MECH. STEAM	16	42	16	1	54	26'-0"	C	3640	23.9	1⅞	10	125	540	200
NECHES	2	15,300	1440 †	390	3	8050	0.526	NATURAL GAS FUEL OIL	A		MECH. STEAM	12	39	16				C	3712	24.2			258	700	200
KIPS BAY	3	10,670 3444 †	668	290	2		1.3	BIT. PULV. W. VA.	A	2	MANUAL	6		10	5	1-36 2-48 2-42 1-30	21'-6" 24'-6" 21'-0" 28'-0"					•			
BEACON ST.	3	2-41,500 1-42,370	NONE	175	4	16,700	0.4	MINE RUN BIT. W. VA. KY & S. OHIO	A	1	MAN.	36 40	21		5 6	54	22'-3"								
MINNEQUA	7	12,000	NONE	165	3			B. F. GAS PULV. C. SLACK SCREENINGS	A	2	MAN.	16			4			C					149 264	515 630	200
MASSILLON	6	6-8400	5-235	315	3	PULV. 6500 STOKER 2375	0.73 0.27	B. F. GAS-PULV. C. COKE-BIT. COAL OHIO SLACK	A	1	MECH.	22	32		4	42	20'-0"		760						
THREE RIVERS	7	10,160	1201 †			8200		FUEL OIL NOVA SCOTIA SLACK PA. SLACK-PULV.	A		MECH.							C	2800				100	150	

†-WATER WALL SURFACE ‡-INCLUDING HEATER SURFACE △- " " WATER WALLS A = AUTOMATIC M = MANUAL C = CONVECTION R = RADIANT

*-IN ADDITION THERE ARE 16 OTHER BOILERS TOTALING ABOUT 25,000 HP NORMALLY OPERATING AT 250% OF RATING.

NOTE: FOR TYPES OF BOILERS AND ARRANGEMENT OF BAFFLING SEE FIG. 1, ARTICLE ON FURNACE AND DRAFT PRACTICE

rear walls and furnace bottom are of the water cooled type with refractory faced block. In the Bayside plant, very little refractory was installed in the furnace walls. In the side walls of the furnaces the water tubes extend only to the top of the ash hopper, the hopper being of refractory construction. No part of these walls or of the refractory furnace walls admit air to the furnace, since the air all comes in at the burner.

At the Kips Bay plant fin tube furnace side walls are connected to the boiler circulating system and installed behind the arch on each side of the furnace, in the path of the upgoing gases. The effect is to decrease the furnace temperature about 200 deg. F. at 225 per cent rating, with a resultant decrease of 50 deg. F. in the uptake temperature of the gases leaving the boiler.

In the Three Rivers plant side wall fin screens and back wall fin screens were provided to reduce the furnace maintenance and reduce the furnace temperature at the high ratings. Air cooled front walls and part of each side wall are refractory lined to insure ignition of coal and complete combustion.

In order to prevent the bottom of the furnace from becoming overheated, a water screen is provided in the Lakeside plant. In Three Rivers plant the distance between the top of the water screen and the under side of the arch was made sufficient so that at all times the flame could be kept above the water screen to prevent slagging the ash in the furnace hoppers.

There have been no unusual developments in the design of superheaters during the past year except that manufacturers are now ready to offer superheaters to furnish steam at a maximum of 900 deg. F. The preferential location of superheaters for high temperatures seems to be in inter deck positions although a few installations have been made of a combination of convection and radiant type, the convection type seems to be used to the greatest extent. Total steam temperatures of over 700 deg. and superheats of over 300 deg. are now used in plants and still higher temperatures are anticipated as soon as valves, fittings and turbines are designed for higher pressures. With increase in pressure and temperature has come a striking increase in capacity. It is not now unusual for superheaters to be called upon to furnish 250,000 to 300,000 lb. of steam per hour from a single unit. The superheaters for the next Hell Gate boilers are to superheat 400,000 lb. per hr. and those to be added to the Fordson boilers, 500,000 lb. per hr. These capacities result in very high gas temperatures in the superheater zone and high heat resisting material must be used for supporting the superheater unit. The superheater designed for the Solvay Process Co. which is to operate at a pressure of 804 lb. per sq. in. was designed for 120,000 lb. of steam per hr. to a final temperature of 735 deg. F. The headers of this superheater are of solid steel, bored to size. There is a metal ball joint connection between the unit and the header.

Soot blowers have become standard equipment in power plants and do the major part of the work of keeping the tubes clean. The size and arrangement of tubes should be such that the soot blower can clean the tubes thoroughly and with a minimum of steam or air, and designs are more and more conforming to this requirement. Adjustable soot blowers are now available. These give considerable flexibility.

It has been found possible by properly proportioning the surface of the boiler, economizer and air heater to maintain any desired exit gas temperature. By this means the overall efficiency of the boiler has been maintained at a high point and marked increases of pressure have been made without sacrificing boiler efficiency.

Conserving Heat Increasing in Importance

Higher Temperatures of Combustion Air and Extensive Application of Preheaters Are Features in Advance Practice

ECONOMIZER USE has been stimulated by the use of higher steam pressures, permitting higher feedwater temperatures so that in some places both air heaters and economizers prove economically justifiable. In many stations economizers have had the exceedingly desirable effect of flattening the efficiency curve so that when the station is operated at a maximum over a long period of time, as is often necessary, there is no great falling off in efficiency. In the Stanton plant a high pressure air-water economizer was used. This absorbed heat from the preheated air instead of from the flue gas as is usual. The purpose of this arrangement was to enable the air preheater to recover as much heat from the flue gas as possible, at the same time permitting the economizers to have their usual effect of flattening the efficiency curve and also to eliminate economizer tube corrosion. The economizer is built with fin tubes like a generator air cooler, but is designed for higher pressures. The air after passing through the preheater was used for the economizer in order to lower its temperature enough to make it practicable to use it under chain grate stokers. At high temperatures the volume of the air is so large that high velocity through the fuel bed is required in order to supply the requisite amount for proper combustion.

Tubes are kept clear of soot by mechanically operated scrapers which move slowly and continuously up and down the tubes. The location of the economizer is usually above the boiler as shown in the chart of typical arrangements of boilers illustrated in the article on furnace and draft practice. The number of square feet of heating surface per boiler seems to vary considerably, running as high as 10,000 sq. ft. in the Des Moines and Kipps Bay plants and as low as 2800 in the Whippany plant.

Increasing use of pulverized fuel has made possible higher preheating of air and avoidance of necessity of supplementing air introduction through brickwork. It is now common to introduce part of the heated air as primary air mixed with the pulverized fuel and the rest as secondary air around the blowers. The introduction of secondary air at an angle of fuel admission in order to increase turbulence is gaining favor. Drawing air from between double furnace walls as in the Lakeside plant is being practiced in several plants.

Preheated Air Benefits Combustion Process

Benefits of highly preheated air both for stokers and for powdered coal firing are becoming more generally realized. Developments in air preheaters have been rapid. It is probable that new stations will install air preheaters of such capacity that flue gases will be cooled

to relatively low temperatures. The square feet of heating surface in air heaters varies considerably. In the Lauderdale plant the air preheater has a heating surface of 82,000 sq. ft. while the Whippany and Three River plants have air preheaters of 6000 sq. ft. Air preheaters are usually located above the boiler and are generally of the plate type. In the Whippany plant while changing the temperature of the air from 70 to 224 deg., the gas loses in temperature from 341 to 218 deg. In the Kipps Bay plant the air is heated to even a greater range; that is from 60 deg. to 527; the gas temperature dropping from 690 to 291 deg. In the East River plant, the temperature of the flue gas passing through the air preheater is reduced to 325 deg. while the air is raised from a temperature of 70 to 544 deg.

In order to avoid the necessity of purchasing a special type of stoker in the Whippany plant, which would be designed for high temperature air, the standard type was purchased and the temperature of the combustion air limited to about 250 deg. Experience has shown that even this small amount of preheat has a marked effect upon combustion efficiency.

In the Whippany plant the air intake passes through the roof; a damper in the duct near the roof permits taking some of the combustion air from the hottest part of the boiler room, thus conserving the heat of the boiler room, or all of the air may be drawn direct from above the roof. In the Stanton plant each boiler is served by two rotary element type air preheaters. The gas leaves the boiler and passes to the two air preheaters which reduce the temperature 440 deg. and increases the temperature of the air to 525 deg. An economizer further reduces the air temperature to about 380 deg.

Combination Water Treatment Methods Prevail

Testing and Treatment of Feed Water Now Carried on with Greater Care. Combination Methods Represent Prevailing Practice

GREATER CARE and accuracy than were heretofore employed mark present practice in the testing and treatment of boiler feed waters and methods of treatment are becoming well standardized. Higher prevailing temperatures and higher rates of steaming cause much higher rates of deposit from a given water hence much greater care must be taken so to prepare the feed water that it is initially in such a condition that a minimum quantity of substance is deposited. Water of zero hardness is most desirable. But water which has been treated to zero hardness may not remain in a most desirable condition especially in high power plants. Air which it has taken up during its cycle of operation must be removed or caustic embrittlement may occur in the materials of which the boiler is made. Removal of oxygen from feed water may not completely inhibit corrosion since other constituents in water are contributory agents, hence in cases of embrittlement careful investigation should be made by a competent person of all conditions involved. Constant re-use of condensate causes it to become acidified or concentrated. In some cases, treatment calls for a slight acidification.

Deaeration and evaporation methods are used in combination with other processes in most high powered plants today and the Zeolite process of water softening is usually added to other treatment methods. In this connection it is well to remember that Zeolite softeners

ECONOMIZERS AND AIR PREHEATERS

NAME OF PLANT	ECONOMIZERS								AIR PREHEATERS						
	TYPE	SURFACE SQ. FT PER BOILER.	ECON. SURF. % OF BOILER HTG. SURF.	LOCATION †	TEMP WATER IN	TEMP WATER OUT	TEMP GAS IN	TEMP GAS OUT	TYPE	NO.	HEATING SURFACE SQ. FT.	CAPACITY LB. AIR PER HR.	AIR TEMP IN	AIR TEMP OUT	LOCATION †
LAKESIDE *	— NONE — USED —								PLATE	1	67,300		70	650	BACK OF BOILER
BAYSIDE	HEATER SECTION OF SINGLE PASS BOILER	7390		PART OF BOILER					ROTARY ELEMENT	4		110,000	70	340	ABOVE BOILERS
STANTON	AIR-WATER	3011	16.7	BETWEEN AIR PRE HEATER+STOKER	203	245	AIR 525	AIR 380	ROTARY EL.	16 2 PER BOILER	40,500		80	525	ABOVE BOILERS
EAST RIVER	— NONE — USED —								PLATE		28900	264,000	70	544	ABOVE BOILERS
MORRELL ST.	HIGH PRESS. STEEL TUBES	5016	52	ABOVE BOILER		372		448	PLATE		10980		70	235	ABOVE BOILERS
DES MOINES	SER	1000	67	ABOVE BOILER	210	315	550	300	PLATE	3	12420		90	190	ABOVE BOILERS
BUCK	— NONE — USED —								PLATE			232 ELEMENTS	112	423	ABOVE BOILERS
WHIPPANY	STRAIGHT TUBE	2880	31.8	OVER REAR ARCH	227	290	515	341	PLATE	5	6170		70	224	BACK OF BOILER
LAUDERDALE	— NONE — USED —								ROTARY ELL. REGENERATOR	1 PER BLR.	82,000	12 PER SQ. FT. GRATE	60	485	ABOVE BOILERS
HARBOR POINT	— NONE — USED —								— NONE — USED —						
NECHES	NONE USED								PROVISION FOR FUTURE INSTALLATION						
KIPS BAY	STEEL TUBE C.I. EXPANDED SURF.	10080	95	IN BREECHING ABOVE BOILERS	200	344	1270	692	PLATE	2	50,000		60	527	ABOVE ECONOMIZER
BEACON ST.	— NONE — USED —								— NONE — USED —						
MINNEQUA	— NONE — USED —								— NONE — USED —						
MASSILLON	INTEGRAL	4600	51	IN SETTING BACK OF BOILER UNIT	205	290 375	550 660	330 430	HOLLOW SIDE-WALL BLOCKS				300	350	SIDE WALLS OF BOILERS
THREE RIVERS	— NONE — USED —								PLATE	7	6363		NOT AVAILABLE		

*-DATA IN CONNECTION WITH 1400 LB. BOILER ONLY.
† SEE FIG 1, ARTICLE ON FURNACE AND DRAFT PRACTICE.

do not function satisfactorily with hot water. Mechanical thickeners, clarifiers and filters are also used extensively for the elimination of suspended solids. Deaeration is carried on in some plants such as the East River Station without the use of a special deaerator.

Use of coagulants, filters and settling basins are used in special cases. Blow-down periods are frequently established in order to limit concentration. At the Massillon Station blow-downs are made every 6 hr. of operation, the amount of blow-down being 3.5 per cent of the total feed. The limit of concentration at this plant is held at 300 grains per gal. Since the necessity for blowing-down is based upon the amount of concentration, there is a tendency to base the periods of blow-down upon the concentration rather than upon the period of operation or in cases of continuous blow-down, which is rapidly being adopted, particularly in large plants, the rate of blow-down is regulated by the amount of concentration. Deconcentrators, in which the heat of blow-down is utilized in an apparatus which is practically a two-stage heater, are based essentially upon continuous blow-down. Both internal as well as external treatment methods are used, but few large boilers are now served with boiler compounds, preference being given, in large power plants, to external removal of impurities.

Feedwater temperatures are being maintained at increasingly higher figures. The high pressure boiler of the Lakeside Station maintains a feed temperature of 325 deg. F. while that of its 1920 boilers is 200 deg. All but one of the 16 plants investigated are equipped with automatic feedwater control. The feedwater at the Lakeside Station is controlled manually. The number of heating stages have been increased to five. Eleven of the plants investigated use closed heaters; six open heaters. Some of these are used in combination. Eleven use extraction steam as their source of heat; eight exhaust steam. Only five depend upon exhaust steam exclusively.

At the Buck Station, make-up water for each turbine is passed into two evaporator feed-water heaters, located on the mezzanine floor at the rear of the condensers. It is discharged by the evaporator feed pump to the pressure heater and then passes to its surge tank which is on the top floor of the boiler room.

Boiler feed water for the high pressure boilers of the Minnequa Station consists of condensate from the turbo units plus the necessary make-up or raw-water. Each condenser is equipped with duplicate hot-well pumps which are connected to separate feeders fed from dual-drive sets. Hot-well pumps deliver the condensate to a reserve feedwater storage tank which takes up the fluctuations in the load. From this reserve feed water tank it is delivered to a deaerator connected with the evaporators for treating the make-up water. The evaporators deliver evaporated water to the deaerator where the entire boiler feedwater supply is dearated to keep the oxygen content below 0.005 c.c. per liter.

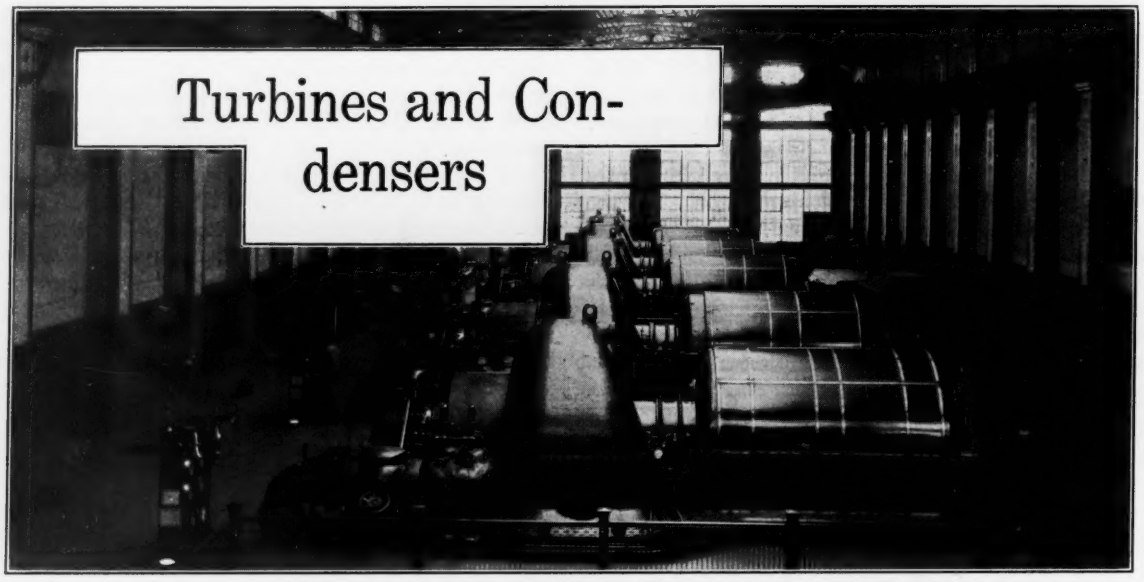
FEEDWATER TREATMENT AND HEATING

NAME OF STATION	TREATMENT		HEATING			STAGE HEATING									
	SOURCE OF WATER	SYSTEM	SOURCE OF HEAT	TYPE HEATER	FINAL F.W. TEMP.	1ST.		2ND.		3RD.		4TH.		5TH.	
						TEMP.	PRESS.	TEMP.	PRESS.	TEMP.	PRESS.	TEMP.	PRESS.	TEMP.	PRESS.
LAKESIDE	LAKE	Tri- Sodium Phosphate Di- " " Soda Ash	EXTRACTION	CLOSED	330	PUMP 75-79	COOLER	15TH STAGE 79-190	3.7	13TH. STAGE 190-200	145	10TH STAGE 200-275	50	7TH. STAGE 275-330	120
BAYSIDE	RIVER	ZEOLITE EVAPORATOR.	EXT.	OPEN			135		17		3				
STANTON	RIVER WELLS	DEAERATOR EVAP.	EXT.	CLOSED OPEN	245		25		6.8						
EAST RIVER	CITY MAIN	DEAER. IN CONDENSER	EXT. EXHAUST	CLOSED	338	EJECTOR 80	COND. 0.6	18 TH. STG. 158	5.1	AUX. EXH. 211	16	14 TH. STG. 269	46	11TH. STAGE 338	126
MORRELL ST.	RIVER	EVAP.	EXH.	CLOSED	372	L.P. 167	5.6	INT. P. 237	20.5	H.P. 423	72.5				
DES MOINES	RIVER WELLS	DEAER. EVAP.	EXT.	CLOSED	315	AIR COOLER 80-88		EVAP. 88-98		HTR. TANK 98-102		L.P. 102-180	HTR. 6	H.P. 180-210	HTR. 27
BUCK	RIVER	EVAP.	EXT. EVAP.	1-OPEN 3-CLOSED	341	AIR PUMP 96-102		L.P. 102-183	ABS. 8.08	EVAP. COND. 177-221		221-266	ABS. 39.1	266-348	ABS. 131.5
WHIPPANY	WELLS	DEAER.	EXT	CLOSED	290	97-168	ABS. 6.5	168-227	ABS. 24						
LAUDERDALE	CANAL	LIME-ALUM-COLD CONTINUOUS DEAER., EVAP., ZEOLITE	AUX. EXH. GLAND STEAM 3 STG. HEATERS	CLOSED	354	3RD.	STG. 68	7TH. 308	STG. 43	3RD. 540	STG. 150				
HARBOR POINT	CITY MAINS	DEAER.	AUX. EXH. — EXT.	CLOSED	210	*									
NECHES	RIVER	DEAER. EVAP.	EXT.	CLOSED	372	88-156	20	156-220	23.4	204-305	90	305-372	203		
KIPS BAY	CITY MAIN	SODIUM PHOSPHATE + CAUSTIC SODA	EXH.	OPEN	344	NONE				USED					
BEACON ST.	CITY MAIN	DILUTE H_2SO_4 UPFLOW SOFTENER DEAER. ZEOLITE	EXH.	OPEN	215	NONE				USED					
MINNEQUA	RESERVOIRS	HOT PROCESS LIME+SODA DEAERATOR EVAP.	AUX. EXH.	COMB.	205	NONE				USED					
MASSILLON	WELLS	LIME+ALUM-COLD CONT. DEAER. ZEOLITE SOLUTION NITRE CAKE	EXT. AUX. EXH.	CLOSED	375	155									
THREE RIVERS	RIVER	DATA UNAVAILABLE		OPEN	180-190*	DATA				UNAVAILABLE					

* HEAT BALANCE VALVES ON 25TH. STAGE OF MAIN TURB. WHICH OPEN AUTOMATICALLY WHEN STEAM FROM AUXILIARIES IS DEFICIENT.

Periodic Sampling and Testing Important

Installation of a propr feedwater treatment system is not the only consideration. Importance rests also, almost equally, with maintenance of the treatment. This requires periodic sampling and testing of treated water to check standard of performance. These tests, which are of a purely routine nature, may be made by properly instructed boiler room personnel.



Matured Practice in Steam Turbine Plant Design

SIMPLICITY OF LAYOUT, REPETITION OF ARRANGEMENT AND INTERCHANGEABILITY OF PARTS, ESSENTIAL FACTORS IN SECURING ECONOMY AND RELIABILITY. BY JAMES W. PARKER*

THAT GOOD STEAM turbine practice is an art will, I think, be conceded if one takes into account not only how many are the factors bearing on successful operation and design, both of turbines and plant assemblies, but the impossibility of predicting the importance of every influence that will ultimately make or mar the result. Being an art, success will, more than in any other way, make its sturdiest growth in a soil whose essential ingredients are appreciation of the conditions determining not only a maintained efficiency but the continued dependability of the power developing unit. It is important, for instance, to appreciate the bearing which simplicity of layout and repetition of arrangement have upon economy of operating force and accuracy of the men's work; likewise that maintenance of machines is simpler and so less costly if parts are kept interchangeable. And not least of all is the appreciation that essential duplication of turbines and their arrangement effects an immense advantage, in that the machine designer can perfect his design in the light of experience with the earlier units and that the plant constructor can perfect his methods in the light of his corresponding experience. It seems almost obvious that the benefit of this advantage will be had in substantial improvement of the machine and a sure minimization of plant investment.

It would be trite to say that the design of any steam turbine must be based on earlier experience but what is not always understood is that any decidedly new design of turbine, to operate under conditions not literally identical with those of some earlier experience, depends in a very real sense on an extrapolation of results. Its performance can only, in the last analysis, be guessed at; the result is in some measure a matter of chance.

Consider what the designer has undertaken in any large multistage impulse turbine and many of the conditions described attend the operation of reaction machines and have similar effects. Upon a forged and machined shaft some 16 ft. long, are strung an assemblage of disc wheels spaced at definite intervals, the whole assembly weighing about 50 t. Rows of blades are attached to the rims of these wheels, a row to a wheel, and the blades vary in length from short, sturdy pickets on the smallest discs to long, warped, wicked looking things nearly 3 ft. long resembling for all the world some Oriental headsman's sword. The whole thing is supported at the ends of the shaft in two self-alining bearings while interleaved between discs are a like number of partitioning diaphragms mounting the nozzles which direct steam upon the moving blades. At places where the partitions, which are stationary, approach the revolving shaft, fragile metal fins act as labyrinth packing to retard the passage of steam between stages. The clearance here between stationary and revolving parts varies from 18 thousandths down to 13 thousandths of an inch. Where the shaft emerges from the steel and iron casing which encloses the rotor, other and more elaborate labyrinth packings cut down the clearance between rotating and stationary parts to 15 thousandths or less.

Difficulty of establishing in the first place clearances down to a few thousandths of an inch between elements of the order of 16 ft. in length is less a problem of machine tools of sufficient precision than it is of the variability both in shape and dimension of the materials of which the machine is composed. In the process of fabrication and assembly obscure fibre stresses are released and set up and, it may be, released again. The shaft itself, the backbone of this exaggerated windmill, deflects some 20 thousandths under its own weight and that of the wheels, for we are dealing with material that is anything and everything but rigid.

To erect such machines, compensating for deflec-

*Chief Engineer, Detroit Edison Co., Detroit, Mich.

tions, adjusting for inaccuracies it may be, realining for foundation settlement, is no small feat but when this much is accomplished, the peculiar hazards with which the machine must cope are still to be encountered. Recollect that this complicated structure will revolve at 1200 or perhaps 1800 r.p.m. and that the peripheral speed at points of minimum clearance is 144 ft. per sec. or more. The steam to drive it will be admitted at possibly 750 deg. F. and a temperature gradient is set up in the metal of rotor and casing, measured by a 700 deg. drop. While one end is subjected to a bursting pressure of several hundred pounds, at the other end the exhaust hood, of complicated shape and large volume, bears a collapsing force aggregating many tons. The elements of the revolving part must withstand both centrifugal force and other complicated systems of forces set up by the passage of high velocity steam through the machine. Under all the circumstances, it is not strange that at times the whole rotor vibrates with even very small unbalance either of the mass itself or of the numerous forces acting upon it, nor that some of the component parts buzz and sing to a tune peculiar to themselves. If even the distribution of pressure and temperature in the several stages remained constant the machine would have a fair chance to accommodate itself and steady down. But both pressures and temperatures vary not only between the standing and running states but vary with changing load. Often when the turbine is standing still, the atmosphere within the casing stratifies and the rotor, heated at the upper side and cooled on the lower, bows and distorts and must be nursed back during the operation of starting until with symmetrical heating it returns to normal shape.

They are "long-waisted darlings," these turbines, and temperamental to a degree. The penalty of a few moments mishandling, a too rapid picking up of speed, a prolonged period of idling, may be anything from a few rubbed buckets to a damaged rotor entailing repairs costing about a quarter of the value of the entire unit. With continued practice, however, operators become familiar with the idiosyncrasies of the creature and develop a surprising skill in humoring and watching it through passing indispositions. They learn to head off trouble or the disturbing factors get killed off, but as Buck Grangerford explained to Huck Finn about the feud, "It's kind of slow and takes a long time."

Designer's Opportunity for Correction Comes After Machine Is Opened Up

After a year or more of successful operation, the machine is opened up for inspection and it is then that the opportunity comes to the designer for making corrections either in the details of his design or in the choice of materials. Corrosion may have appeared in unexpected places, buckets in certain stages may show fatigue cracks caused by vibration that must be tuned out by redesign. Informed now by actual experience, the designer can proceed with the building of a similar turbine with a surer knowledge of results. Duplicate in outline, with all major parts interchangeable, the new machine will nevertheless differ in many seemingly unimportant details and will in consequence surpass its predecessor in reliability and sustained efficiency. If the same process of trial and correction is repeated, not once but twice, the design presently becomes fixed as a breed becomes fixed and operating results, no longer extrapolated, can be predicted with a considerable measure of certainty. If, as occasion arises from time to time to recondition the earlier machines of such a series, these are given the benefit of improvements worked out in the revised design, the whole group may in time be brought to the same high standard of excellence.

With the rapid development of improvements in turbines, there is great temptation to choose new types when the time is come for extending an existing plant. The economics of a given situation may determine the selection of a higher pressure or a different steam cycle and a consequent departure from the earlier type of turbine. Yet such a departure should be made at least with reluctance. There are more objects to aim for in turbine plant design than high efficiency alone and some of them are defeated by major variations in the main units.

Quite apart from any "sudden accidental breaking and/or burning out," as the insurance policies say, there goes on a general wear and tear with months of continued operation. The machine gets "well worn in," clearances become increased here and there but the efficiency gradually slides off. There comes a time when a general reconditioning will pay a high return on the cost. Blading will be found corroded and eroded, shaft packing found impaired and the best thing that can be done for the rotor is to send it back to the manufacturer. But this may spin the shutdown period into months. In anticipation of just such inevitable overhauling, the operator whose plants are equipped with a number of machines of identical dimensions feels warranted in carrying a complete spare rotor, spare nozzles and spare shaft packings, which might be hard to justify as insurance against accident only. Spare parts in this sense include substantially all moving parts of the turbine and all fragile stationary parts in proximity to the rotor that are liable to be damaged by it. To carry such a complement of parts for every one of several different types of machine in the same plant would be just next to impracticable.

And, speaking of investment, your plant constructor grows eloquent on the savings in construction costs made possible by a duplication of machines and their arrangement. It is difficult to point to any single saving that will account for the result. Incidents arise on every hand. Certainly there is less groping, fewer mistakes are made, the work progresses on a known time schedule and much more expertly because of the previous experience with identical equipment. Whatever the exact causes, the fact is and can be demonstrated, that subsequent additions in such a plant have shown lower relative installation costs. And the plant investment reflects not only this but the purchasing advantage which is just as surely attained by the same means.

The argument for improvement and fixation of the type by repetition of the unit, strong enough of itself, is immensely reinforced by these other factors making for increased plant usefulness and the paring down of investment costs. An appreciation of many fine points in turbine room practice confirms it and perhaps not the least is that such a plant is a good one to live with.

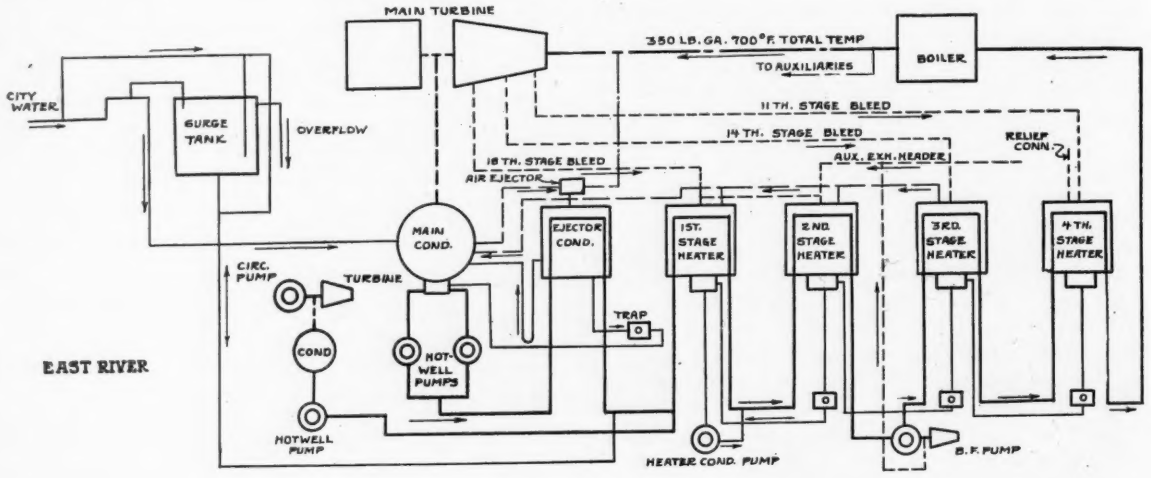
Stage Bleeding Dominates Station Heat Balance

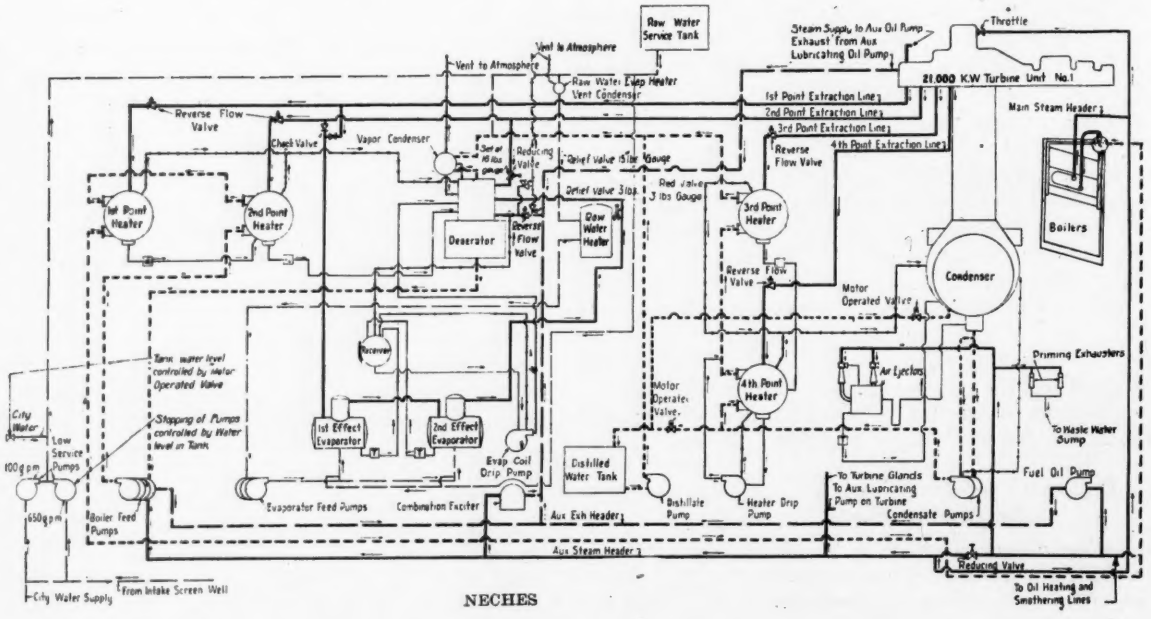
Use of Air Preheaters and General Adoption of Motor-Driven Auxiliaries Increases Utilization of Bled Steam with Corresponding Increase in Thermal and Economic Efficiency

FROM A THEORETICAL heat economy standpoint, the essentials of the modern power station heat balance depend upon a realization that the utilization of any heat for feedwater heating which displaces steam bled from the main unit reduces the amount of electric power generated without a condenser loss.

Practically there are many reasons why theory cannot be followed too closely: station reliability, the necessity for evaporated makeup with present high pressure, high rating boilers, and several unavoidable sources of heat loss. Steam jet condensers, generator air coolers, bearing and transformer oil coolers and high pressure gland leakage are all sources of low temperature heat which are available and cannot be avoided. Their utilization displaces extracted steam at the most advantageous point of extraction. It is, therefore, a case of choosing between two unavoidable losses, the condenser loss of the heat in the steam which necessitates no additional equipment, or loss of an equivalent amount of heat from the other sources which do involve additional equipment if the heat is not absorbed in the condensate.

There is, however, no uniformity regarding these various items. For instance, at Lauderdale, the generator air cooler, generator oil cooler and ejector condenser are all utilized, giving temperature rises of 9, 2 and 4 deg., respectively. Under full load conditions in the average plant, there is sufficient heat dissipated by the generator to heat the condensate from 10 to 13 deg. At Stanton, Des Moines and Bayside, the gen-





erator air cooler and ejectors are used, while at Whippany the oil cooler and ejector condensers are utilized as feedwater heaters. The remaining stations covered in this article make use of the ejector condensers only, the temperature rise throughout them averaging about 4 deg. F. Although auxiliary water is usually provided for emergencies, there is apparently little to substantiate the persistent rumor last year that condensate for this service was being discontinued. Some companies are, however, using raw water on the intercooler and condensate on the aftercooler, where extremely high vacuums are carried.

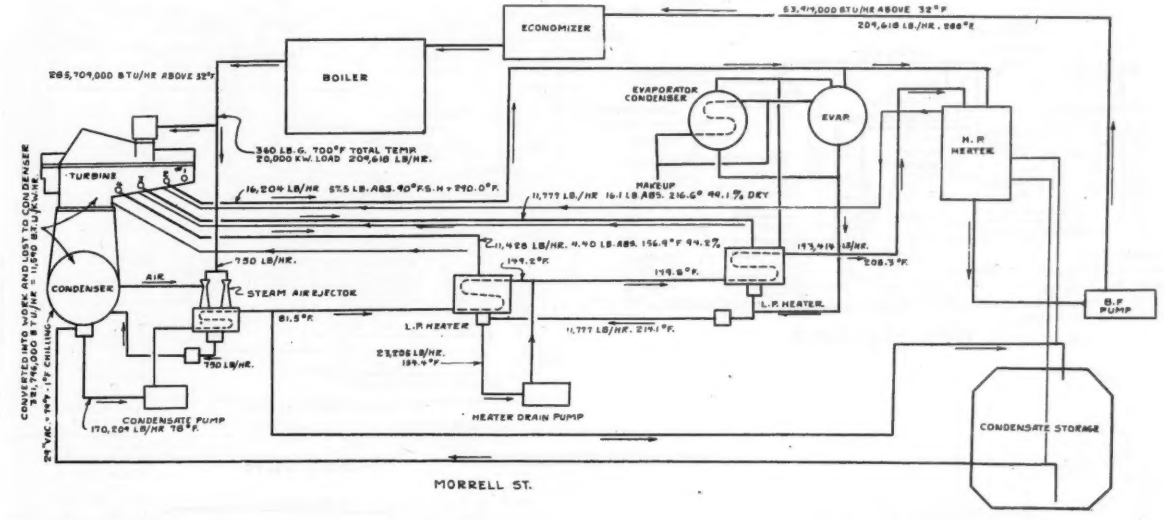
Evaporators are now almost standard equipment, but here again there is little uniformity in their location in the station heat balance. From a thermal standpoint, there is little loss from evaporators, regardless of their location or arrangement.

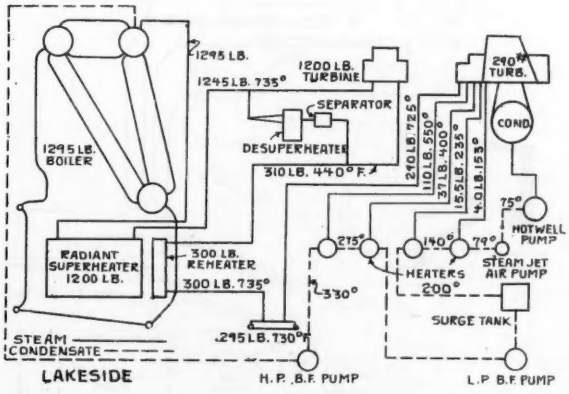
At Stanton the evaporator condenser follows the ejector condenser, while in Des Moines and Lauderdale, high heat level condensers immediately preceding the high pressure heater are used. At both Lauderdale and Morrell, the evaporator makeup is heated in a special heater using the evaporator vapor so that part of the vapor output is absorbed in this manner, resulting in a reduction in the amount of bled steam displaced.

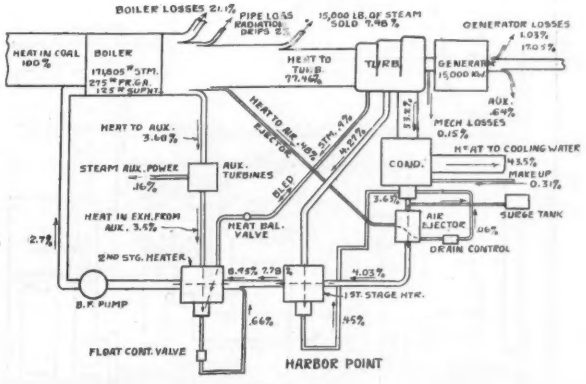
At Lauderdale an open evaporator makeup heater is used, limiting the temperature to the evaporator to 210 deg. At Morrell, a closed heater is used, taking the makeup direct from the high pressure service header. Evaporator vapor not absorbed in the makeup heater goes to the intermediate pressure extraction heater which operates at a pressure of about 16 lb. At this station steam for the high pressure heater and for the evaporator is bled from the turbine at about 57.5 lb. absolute and with 90 deg. superheat. Softened and filtered water is often used for the evaporator supply. This is done at Bayside where steam bled at 17 lb. abs. is used for the evaporators with an arrangement so that during periods of low load the evaporator will take steam from the auxiliary exhaust header.

Deaerating heaters are being widely used. At Morrell the high pressure heater is of the open deaerator storage type, designed to heat the feedwater from 217 to 312 deg. At Stanton the open deaerating heater precedes the air-water economizer which absorbs heat from the preheated air instead of from the flue gas direct. This gives the usual and desirable economizer effect of flattening the efficiency curve while eliminating the usual economizer trouble due to corrosion. It also serves the purpose of tempering the preheated air going to the stoker and the flow of feedwater through it is controlled so as to maintain this temperature constant.

Reheating of the steam after it has completed a portion of its expansion has proved practical and successful where applied. Stanton is the only reheat station which went into service this year, but the new State



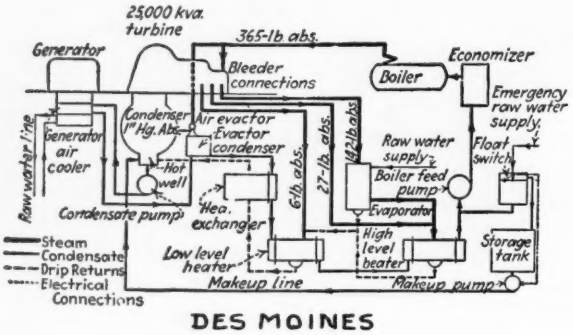




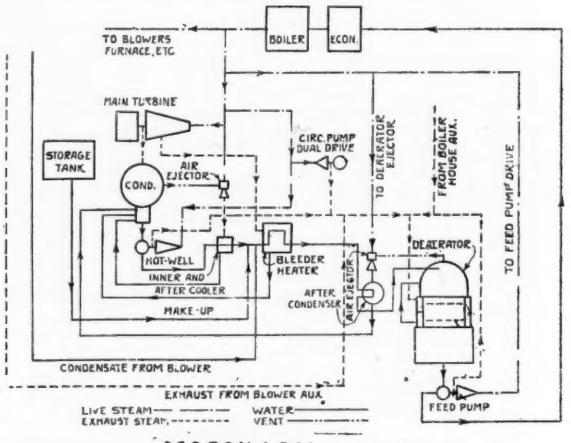
Line Station will use steam reheaters and the new Powerton station, which is now under construction, will use standard and reheat boilers as installed at Stanton.

Stage bleeding in from two to four stages for feed water heating and evaporation is now standard practice.

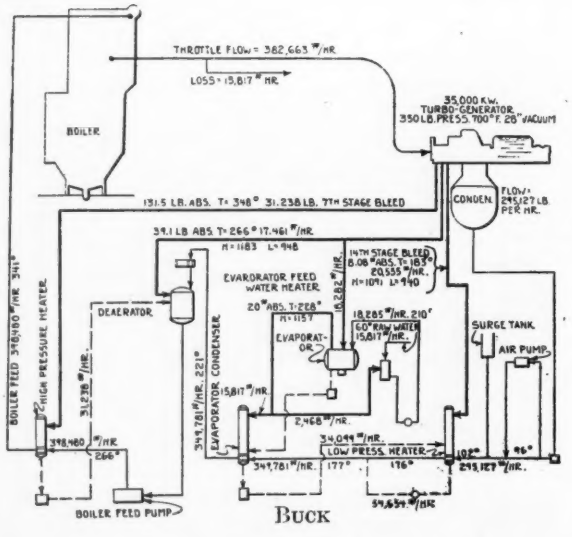
Reliability is the determining factor in determining the uses to which motor drive for the auxiliaries can be applied. The majority of companies have concentrated upon increasing the reliability of the electric supply by increasing the number of sources of power with automatic protection, although a number of companies use the house generator mounted on the shaft of the main unit as at Stanton. The house turbine has practically been eliminated as far as its position in the heat balance is concerned. Separate units are now considered largely as another source of auxiliary power or means of starting up the station.



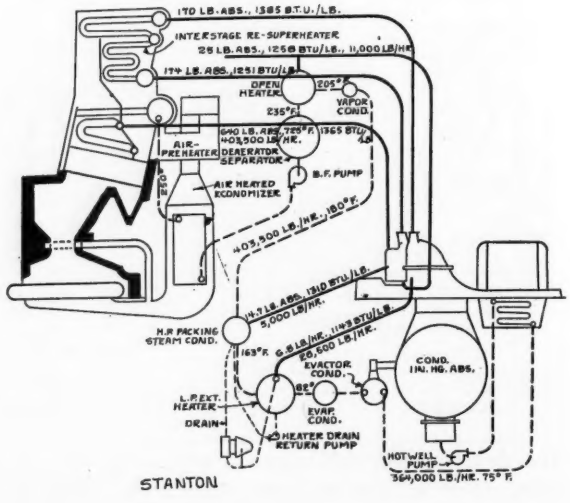
DES MOINES



MASSILLON



BUCK



STANTON

One New Station Uses Steam-Driven Auxiliaries

At East River it was determined to adhere to the usual practice of the New York Edison station and use steam drives for the essential units on which continuity of service depended. This, however, is but one company's opinion. In fact, the tenacity with which certain companies cling to their accepted layouts makes it appear that there is little to choose between them in the way of efficiency.

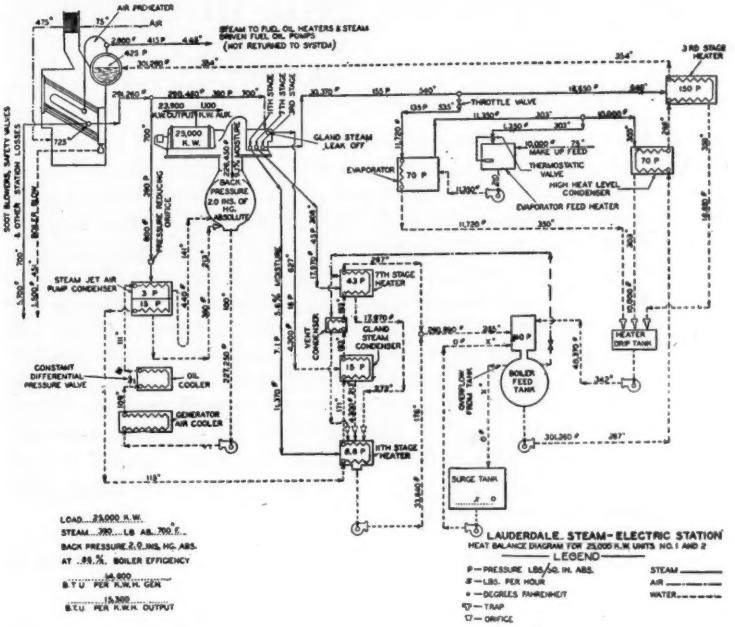
The economy of standardization in design and equipment is apparent as from a similarity of design in several plants of the same company it appears that having once gone into the subject thoroughly and determined to their own satisfaction by experience what they consider the most satisfactory design, there is not thermal advantage enough in changing to different or newer arrangements to make the change or gamble worth while.

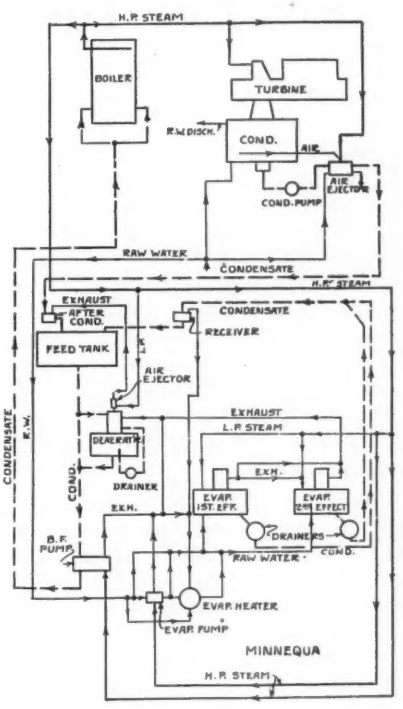
Stage extraction from the main unit, the general adoption of air preheaters, and the trend toward completely motor-driven auxiliaries are so interrelated that it is difficult to interpret their respective influence on the station heat balance. Undoubtedly stage extraction is largely responsible for the adoption of the motor drive for auxiliaries although there are several minor factors to be considered as well. Besides the elimination of considerable piping with its corresponding heat loss, the makeup is greatly reduced and the station improved from an operating standpoint. Two per cent makeup is a conservative value for the modern station, 3 per cent is excessive and Stanton, one of the most recent stations to go into service, is laid out on the basis of 1½ per cent makeup.

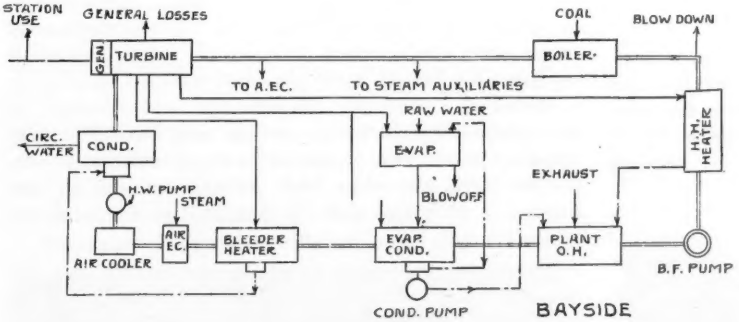
It is interesting to note the growing importance of the bleeder mixed flow and high pressure turbine in the industrial plants. Where large quantities of process steam are used power amounts almost to a by-product, and industrial engineers, somewhat slower than the central station men to take advantage of extraction universally, are now losing no time in applying it to their power problem, although as a rule their heat balance, complicated as it is by industrial requirements, is much more complex.

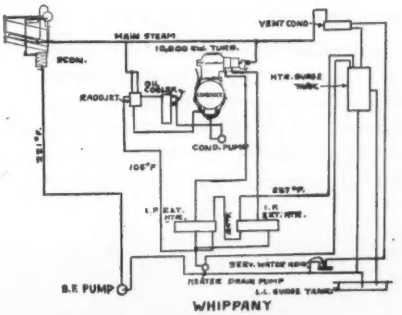
feed pump. This open heater is often operated at pressures above atmosphere and has some storage capacity to take care of slight load variations, although it is considered necessary to have a larger surge tank somewhere in the system. Many of the newer stations favor the introduction of water from the surge tank into the condenser hotwell, as at Morrell.

Adoption of motor-driven auxiliaries and of air preheaters has, of course, greatly widened the field for extraction steam. The motor drive affects the heat bal-



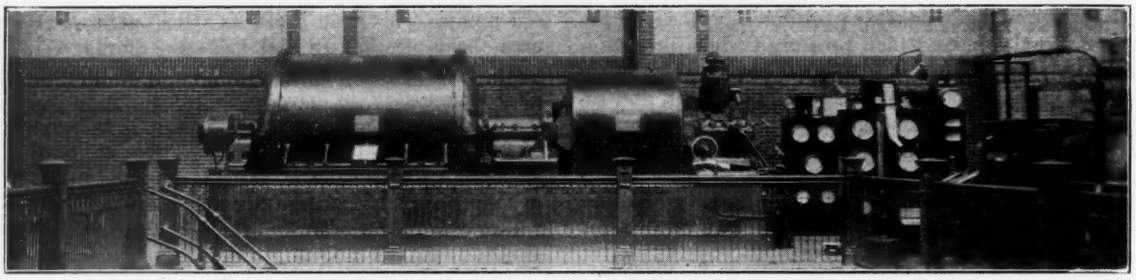






Viewing the development during the past year, there are several trends apparent. Stage extraction for feed heating and evaporation may now be considered universal. Motor drive, except in a few isolated cases, is practically universal, dependence being placed on various electrical sources either from the same station or through interconnection. Hotwell pumps are now designed to pump against a considerable head and force the condensate through several heaters, delivering it either direct to the suction of the boiler feed pump or to an open storage heater immediately preceding the boiler

ance below 210 deg. by eliminating the auxiliary turbine exhaust, and the air preheater affects the heat balance over 210 deg. F. by making it possible to send the feed water to the economizer considerably above the temperature formerly considered possible, or, by making it possible to eliminate the economizer entirely, absorbing the heat of the flue gas in the preheater. The air preheater thus affects the economy of the station by increasing the temperature and efficiency of the furnace, by cooling the flue gas to any desired point and by increasing the demand or utilization of exhaust steam.



Limit of Turbine Development Not in Sight

INSTALLATION OF RECORD BREAKING 104,000-KW. UNIT AT CRAWFORD AVENUE TO BE EXCEEDED BY A 208,000-KW. UNIT AT STATE LINE, WHILE A UNIT IN EXCESS OF 300,000 KW. HAS BEEN OFFERED BY ONE MANUFACTURER

PROBABLY the outstanding feature of the year from an operating and thermal standpoint is the Lakeside 1200-lb. turbine. Continuous operation over long periods of time under high load factor has confirmed the operating possibilities indicated by the first high pressure unit at Edgar. Careful tests show the 1200-lb. equipment is 10 per cent more efficient than the 300-lb. equipment in the station and that the operation of the station as a whole is improved about 3 per cent by the addition of the 7000-kw. high pressure turbine. A view of this unit installed is shown in the headpiece of this article. A view of the operating end of the turbine is shown in Fig. 1.

Based on the results of the first high pressure 3000-kw. turbine a second high pressure unit rated at 10,000 kw. is being installed at Edgar. The massive cylinder construction of these high pressure turbines is shown in Fig. 2, a photograph of the turbine being installed. The Lakeside unit and both of the Edgar units were built by the same manufacturer. Recently an order was placed with another manufacturer for a 10,000-kw., 1200-lb. turbine for an addition to the Northeast Station in Kansas City, the third central station in this country to adopt this high pressure.

Although the Kansas City turbine is the first 1200-lb. unit supplied by this manufacturer, an 800-lb. unit which this company built has been in service for some time at the plant of the Solvay Co. at Syracuse, N. Y. In the industrial field this unit ranks with the original unit at Edgar in pioneering importance.

Prospects of the commercial success of the mercury vapor cycle were considerably brightened during the past year by the success of the three-stage turbine which went into service in the Dutch Point Station at Hartford late in 1926. Based on the successful operation of this unit, a 10,000-kw. turbine, representative of the five designs to be placed on the market, will go into service at the South Meadow Plant early in 1928. This will be a five-stage machine receiving vapor at about 70 lb. pressure and exhausting it at 1 lb. absolute to two mercury condensers which will, in turn, generate 125,000 lb. of steam per hour at 250 to 350 lb. This steam will be superheated by the mercury boiler furnace flue gas to 700 deg. F. and will be used to generate about 10,000 kw. additional.

MERCURY VAPOR CYCLE WOULD INCREASE EFFICIENCY OF COLUMBIA FROM 27 TO 36 PER CENT

It is claimed that the remarkable record of 27 per cent thermal efficiency obtained at Columbia could be increased to 36 per cent if designed to operate on the mercury steam cycle. The operating company claims that in the present Dutch Point Station it has been able to obtain as good a coal economy on 5 per cent capacity factor with the mercury unit as the entire station is capable of doing on a 60 per cent capacity factor. As a means of increasing the capacity and economy of the existing station or in placing new base load high economy plants, this system of power generation is competitive with the ultra high pressure generation and utilization of steam with its attendant steam reheating

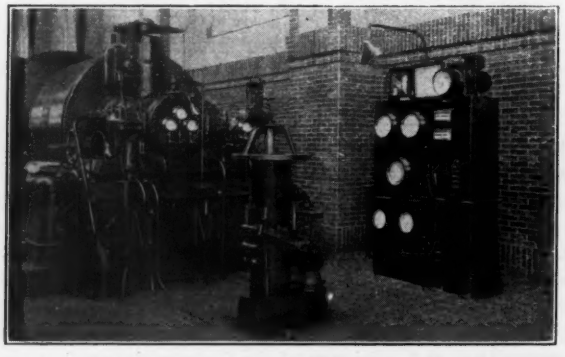


FIG. 1. CONTROL END OF THE 7000-KW., 1200-LB. TURBINE AT LAKESIDE STATION

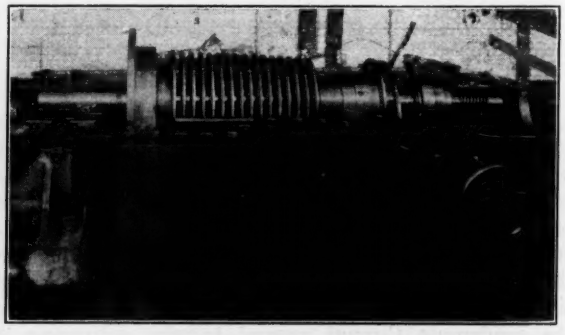


FIG. 2. VIEW OF THE 10,000-KW., 1200-LB. TURBINE BEING INSTALLED AT EDGAR STATION

complications and relatively large auxiliary power consumption.

Stage bleeding is now accepted standard practice, and the practicability of the reheat cycle with moderately high pressures (500 to 600 lb.) has been proved conclusively by a number of stations including Columbia, Crawford Ave., Philo and Twin Branch. Practically all of the larger turbines installed or ordered last year were designed for two, three, four or five-stage extraction.

At Harbor Point only two of the four extraction points will be utilized, as the expense of four-stage feedwater heating could not be justified while the station is on standby service. The new 165,000-kw. unit at Philo, on the other hand, under base load conditions, will be bled at five points for feed water heating, the highest point at 365 lb. absolute, and the lowest at 6.15 lb. absolute. Steam will be delivered to the high pressure element at 600 lb., 725 deg. F. and the initial pressure of the steam to the low pressure element will be 126 lb. absolute, 725 deg. F. after reheating.

Extensive inter-communication and interconnection make it economical to install large generating units. As an indication of the trend towards larger sizes, it has recently been decided that in the future no turbines of less than 50,000-kw. output will be installed in Chicago and adjacent territory. The motive of large machines is not so much better fuel economy as it is reduced plant investment ,and the desire to keep the total plant capacity in as few units as possible.

It is expected that the installation of these large machines will continue, although it is impossible to predict a final limit. With the exception of the 60,000-kw., single cylinder units at East River Station, the stations listed in the tables do not show this trend towards the larger machines. A similar 60,000-kw. unit was put into service the latter part of this year at Huntley Station in Buffalo, while a 50,000-kw. tandem compound unit in the addition to Waukegan station has been in operation for several months. The largest unit of the year has been the 104,000-kw. cross-compound unit at Crawford Avenue.

This, however, has been somewhat overshadowed by the much discussed 208,000-kw., cross-compound, three-element turbine for the State Line plant, the 165,000-kw., cross-compound unit at Philo, the 160,000-kw. unit for Hell Gate, the 108,700-kw., cross-compound unit for Hudson Avenue, the 94,000-kw. tandem compound unit for Long Beach and the 65,000-kw., single cylinder unit at Edgar. The first is the largest unit ever built, although one manufacturer offers a machine in excess of 300,000 kw. The last two are respectively the largest single shaft turbine and the largest single cylinder turbine at present constructed.

STEAM TURBINES

NAME OF STATION	NO OF UNITS INSTALLED	TYPE	RATED CAPACITY-KW.	NO. OF STAGES OR ROWS	SPEED R.P.M.	THROTTLE CONDITIONS PRESS. ABS.	THROTTLE CONDITIONS TEMP. °F.	EXHAUST PRESS.	EXTRACTION STAGE	EXTRACTION ABS. PRESS.	EXTRACTION TEMP. °F.	EXTRACTION PURPOSE
LAKESIDE *	1 1	IMPULSE IMPULSE	7,000 30,000	20 17	3600 1800	1245 300	725 725	325 † 1 IN.	7-10-13-15	110-37-15.5-4.0	550-400-235-15.3	FEED HEATING
BAYSIDE	2	REACTION	10,000	60	1800	340	720	1 IN.		135-17-3	350-219-141	FD. HEATING & EVAP.
STANTON ‡	4	IMPULSE	45,000	19	1800	615	725	1 IN. ‡	12-16	25-6.8	240-177	FD. HEATING + EVAP.
EAST RIVER	2	IMPULSE	60,000	20	1500	390	700	1 IN.	11-14-18	126-46.4-5.1	345-276-163	FD. HEATING + EVAP.
MORRELLST.	3	REACTION	20,000	30	1800	400	730	1 IN.	2-11-21-26	72.6-20.5-5.4	?-423-276-163	FD. HTG. & EVAP.
DES MOINES	1 1	IMPULSE IMPULSE	20,000 30,000	14 17	1800 1800	365 365	645 645	1 IN.	3-6-11 10-12-14	142-27-6 160-25-6	354-244-170 358-240-183	FD. HTG. & EVAP.
BUCK	2	IMPULSE	35,000	17	1800	365	700	1 IN.	7-11-14	131.5-39.1-8.08	348-266-183	FD. HTG. & EVAP.
WHIPPANY	2	REACTION	10,000	60	1800	290	665	2.5 IN.		24-6.5	236-174	FD. HTG.
LAUDERDALE	2	IMPULSE	25,000	14	1800	390	700	2	3-7-11	155-45-7.1	5.40-308-178	FD. HTG. & EVAP.
HARBOR POINT	2	REACTION	15,000	32	1800	290	540	1.5 IN.	2-18-25-29	?-?-22.2-6.75	?-?-234-175	FD. HTG.
NECHES	1	REACTION	21,000	60	1800	365	700	2	2-8-16-19	283-90-234-6.0	605-385-245-170	FD. HTG. - EVAP.
KIPS BAY	2	IMPULSE MIXED FLOW	3,000	5	3600	290 OR 165	414 OR 371	165 OR 20 LB.	1	165	371	HEAT BALANCE
BEACON ST.	3	IMPULSE	2400 3000 3000	9 7 1	3600	160	363	20 LB. 55 TO 135 * 20 LB.	← NO →		EXTRACTION →	
MINNEQUA	3 4	REACTION IMPULSE	10,000 5,500 HP	9 —	1800 2950	315	630	2 IN.	← NO →		EXTRACTION →	
MASSILLON	1 2	IMPULSE IMPULSE	10,000 5,300 HP	9 8	1800 4150	268	565	1.5 IN. 1.5 IN.	6	9 NO.	186 EXTRACTION	FEED HTG. →
THREE RIVERS →			BOILER				ROOM			ONLY		

* LAKESIDE HAS 2-20000 KW., 4-30000 KW. AND 1-7,000 KW. TURBINES. THE TWO COVERED ABOVE WERE INSTALLED WITH THE 1400 LB. BOILER ROOM (NO. 3
† EXHAUST AT 325 LB. ABS.- REHEATED IN RADIANT REHEATERS AND DISCHARGE TO 300 LB. MAIN
‡ REHEATED IN STANDARD REHEAT BOILER FROM 480 DEG. F. TO 725 DEG. F. AT 175 LB. ABS. BETWEEN 7TH AND 8TH STAGE

Two interesting features of design of the Hudson Avenue Station are the five governor control valves in two steam chests and the stainless steel blading. This is a two-element unit, with the main generator fields alike, so that they may be used on either stator. Shaft ends will be made similar for this purpose. The Hell Gate unit is unusual because of its flat efficiency curve. At present it will be required for normal service on 50,000 to 100,000 kw., but in the event of one or more of the existing units failing, it must be able to take up to 160,000 kw. continuously.

Steam Reheater Used at Crawford Avenue

The 104,000-kw. unit at Crawford was designed as a base load unit with the leaving loss reduced to a minimum. It is approximately 1 per cent of the most economical load and 1¾ per cent of the maximum load, each figure assuming steam extraction at four points for feed water heating. Steam is supplied to the high pressure element at 565 lb. absolute, 725 deg. F., and is expanded to about 40 lb. absolute. It is then re-

heated by means of a steam reheater to 500 deg. F. before entering the double flow intermediate element. One-third of the steam flow then passes in one direction and is completely expanded, while two-thirds of it passes in the opposite direction, expanding to 8 lb. absolute. It is then passed to the double flow low pressure element which is in the same line of shafting as the intermediate element. By this arrangement steam is exhausted to six condensers at three points.

Trends toward higher speeds are evident and an 89,412-kv.a. machine has been designed for 1800-r.p.m. Fifteen hundred revolutions per minute for 25 and 50-cycle and 1800 r.p.m. for 60-cycle machines are now standard for the larger sizes, while units of 10,000 kw. have been built for 3600 r.p.m. Temperatures remain about the same as during last year, and have been limited in this country to 750 deg. F. with the usual operating temperatures ranging from 700 to 725. It is reported that these temperatures have been exceeded in several European plants, although there is nothing to indicate that higher temperatures are being contemplated in this country before the results of research in this direction now under way are known. Undoubtedly there will be an endeavor to resort to higher temperatures later, but whether this increase will be in decided steps by using special alloy steel or whether there will be a gradual increase from year to year cannot be predicted at present.

Varied Condenser and Auxiliary Demands Met

DECREASING UNIT SURFACE, USE OF DIVIDED VERTICAL CONDENSERS, CIRCULATING WATER FROM A COMMON PRESSURE TUNNEL, AND VERTICAL CIRCULATING PUMPS ARE THE OUTSTANDING FEATURES OF THE YEAR

DURING THE PAST YEAR a number of refinements have been made in condenser and condenser auxiliary practice and equipment which are expected to do much toward reducing the overall cost of condensing service. Factors governing the performance of condensers are coming to be better understood and this end of the plant has received much attention recently from both operators and manufacturers in an endeavor to increase the efficiency. Condensers are now chosen on a capitalized basis where initial cost, vacuum, auxiliary power consumption and reliability are considered and given a monetary value.

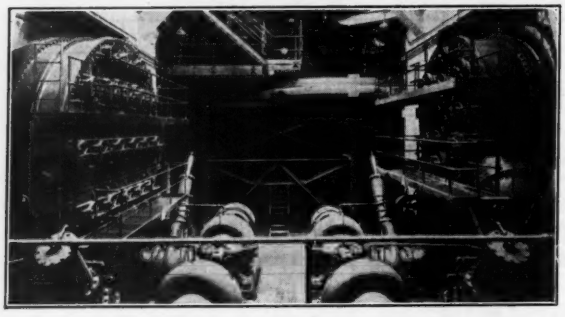


FIG. 1. CONDENSERS NOS. 5 AND 6 AT LAKESIDE STATION SHOWING THE CONTRAST IN SIZE OF ONE AND THREE-PASS CONDENSERS FOR THE SAME SERVICE

The decided trend toward the single pass units which has been evident the last two years is becoming well defined. Both the two pass and single pass types have, however, definite applications, and there is no possibility of one displacing the other entirely. The single pass is particularly adapted to conditions where a generous supply of circulating water is available.

When used, the single-pass type allows a considerable reduction in size and surface. Figure 1 shows condensers Nos. 5 and 6 at Lakeside Station, both serving similar 30,000-kw. turbines under practically the same conditions. The one on the left is a 3-pass, 50,000-sq. ft. unit; that on the right is a single-pass, 25,000-sq. ft. unit. Both of them were supplied by the same manufacturer.

Of the stations tabulated in the table, perhaps the outstanding installation is at Stanton. Single-pass condensers are used with the piping arranged so that the flow through them can be reversed in order to clean the tubes and tube sheet of debris. Circulating water is supplied and discharged through concrete pressure tunnels, with the pumps, one for each unit, grouped at one end of the station, where any pump can be used to supply any condenser. An ice melting pump, which can also be used as a circulator, is installed to recirculate warm discharge water back to the river intake to combat ice formation.

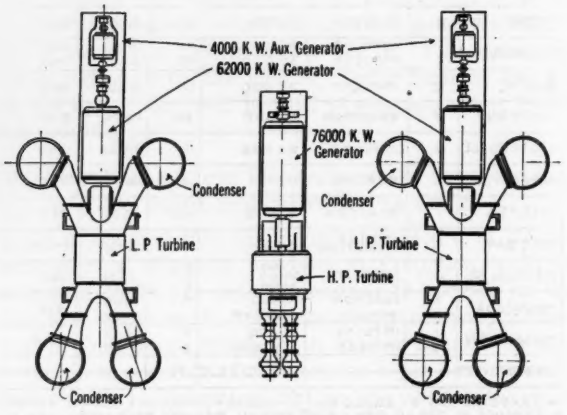


FIG. 2. ARRANGEMENT OF THE EIGHT CONDENSERS WHICH WILL BE USED WITH THE 208,000-KW. STATE LINE TURBINE

TUBES ROLLED IN BOTH TUBE SHEETS

Tubes are rolled into both heads of the condenser in order to eliminate leakage, as the water from the coal field surrounding the plant is particularly bad. These condensers have one rigid tube sheet, the other being a floating head supported on guides and with a rubber expansion joint between the tube sheet and condenser shell.

This construction is similar to that which has been in service for some time in the Trinidad Station at Texas. Tests have been most gratifying. Leakage is exceedingly small and the tubes appear to give no

CONDENSER DATA

NAME OF STATION	NO. OF UNITS	TURBINES KW-RATING	TURBINES STEAM EXTR.	SURFACE TOTAL	SURFACE SQ.FT/KW	STEAM FLOW TOTAL	STEAM FLOW LB/SQ.FT.	CONN. TO TURB.	TYPE HOTWELL	VAC. REF. TO 30"	PASS.	WATER BOX	CIRCULATING WATER TUBE VELOCITY	CIRCULATING WATER G.P.M.	CIRCULATING WATER G.P.M./KW	CIRCULATING WATER STEAM RATIO	TUBES	PACKING
LAKESIDE*	1	30,000	4 PTS.	25,000	.83	243,000	9.72	RIGID	STD.	1"	1	SINGLE	7	53,000	1.66	103	1-⅞-⅞ O.D. 18 BWG. BRASS	CORSET LACE
BAYSIDE	2	10,000	3 PT.	12,700	1.27	45,000	7.48	R.	STD.	1"	2	S	4.96	25,800	2.58	136	ADM.	COR. LACE
STANTON	4	45,000	2 PT.	33,000	7.34	36,400	9.7	EXPAN. JOINT	STORAGE	1"	1	S		72,000	1.6	99	1-⅞-⅞ 18 ADM	ROLLED
EAST RIVER	2	60,000	3 PT.	45,000†	75	520,000	11.55	R.	DEAERATING	1"	1	S	7.1	90,000	1.5	86.5	⅞" ADM. 18	COR. LACE
MORRELL ST	3	20,000	3 PT.	27,000	1.35	175,000	6.5	R.	DEA.	1"	2	S	7	36,000	1.8	103	1" 18 MUNTZ	1 ROLLED 1 METALLIC
DES MOINES	1 1	20,000 30,000	3 3	27,600 45,000	1.33 1.5	200,000 270,000	7.25 6.0	R R	DEA. DEA.	1" 1"	2 2	S S	5.9 5.9	34,000 50,000	1.7 1.76	85 92.5	18-CU. ZIN. ALLOY 18 MUNTZ	COR. LACE " "
BUCK	2	35,000	3	54,000	1.54	295,127	5.46	R	STD.	1-2"	2	DIVIDED	6.3	66,000	1.86	91	1" OD. MUNTZ 16-1"-2"-16 18 BWG.	FIBER
WHIPPANY	2	10,000	2	17,850	1.785	101,830	5.71	R.	STD	1.5	2	DIV.	1 4.5	15,300	1.53	75	1" ADM. 18 BWG.	MET.
LAUDERDALE	2	25,000	3	20,000	.8	226,540	11.32	EXP.J.	SEPARATE	2	1			50,000	2.50	110	1" ⅞+⅜" 18 BWG. ADM.	COR. LACE
HARBOR POINT	2	15,000	4	20,000	1.33	180,000	9	R	STD.	1.5	2	DIV.	6.6	25,000	1.25	69.5	1" OD. 18 MUNTZ	COR. LACE
NECHES	1	21,000	4	35,000	1.67	210,000	6	R.	STD.	2.	2	DIV.		44,000	2.10	105	ADM.	
KIPS BAY	—	—	—	—	—	—	NO CONDENSER EQUIPMENT											
BEACON ST.	—	—	—	—	—	—	NO CONDENSER EQUIPMENT											
MINNEQUA	3 4	10,000 5,500 HP‡	0 0	13,000 4000	1.5 .97	90,000 40,000	6 10	R R	STD. STD.	1.5 2	2 2	S S		12,000 4,000	1.2 .97	66.7 50	18 ⅜ ADM.	MET. FIBER
MASSILLON	1 2	10,000 5,200 HP‡	1 0	14,400 6400	1.44 1.62	126,000 50,000	8.7 7.8	R. R	STD. STD.	1.5	2 2	S S	5 4.6	16,100 7,000	1.61 1.76	64.5 70.0	¾ MUNTZ	COR. LACE
THREE RIVERS	—	—	—	—	—	NEW ADDITION		BOILER PLANT ONLY										

* - SEE FOOTNOTE ON TURB. TABLE - TOTAL CAPACITY LAKESIDE 167,000 KW. WITH 6 CONDENSERS. THIS DATA COVERS ONLY THE LATEST ADDITION WITH THE 1400 LB. UNIT.
† - 2500 SQ.FT. EXTERIOR AIR COOLER
‡ - DRIVE CENTRIFUGAL BLOWERS, RATED IN HP, MAX. VALUES GIVEN

trouble from loosening in the tube sheet. This alone is remarkable demonstration of the effective way the problem of steam distribution has been solved. If the distribution of steam were not uniform, temperatures of the different tubes would vary and some of them would soon work loose. At the Powerton station especially arranged valves in the shell of the single-pass condenser will be used to reverse the flow.

Measured by steam capacity, condenser sizes have kept pace with the growth of turbines, but because of construction and installation difficulties, the large turbines have been provided with divided units. These divided units are usually of the vertical single flow type. The 104,000-kw. turbine recently put in operation at Crawford Avenue is provided with six such units with 15,000 sq. ft. of condensing surface each. The condensing capacity totals 730,000 lb. of steam per hour. Condensing water will be supplied at the rate of 180,000 g.p.m. by two vertical pumps. This circulating water is sent up through a center pipe and discharged downward through the tubes. Any one of the eight units can be cut out at any time without affecting the operation of the other units except insofar as it reduces the total condensing surface.

At the Long Beach Plant, the 94,000-kw. tandem compound unit will be installed with four vertical single-

CONDENSER AUXILIARIES PER UNIT

NAME OF STATION	COND. SURF.	SOURCE OF AUXILIARY POWER	CIRCULATING PUMPS NO.	CIRCULATING PUMPS CAPACITY EACH	CIRCULATING PUMPS CAPACITY TOTAL	CIRCULATING PUMPS TOTAL HEAD FT.	CIRCULATING PUMPS DRIVE	HOTWELL PUMPS NO.	HOTWELL PUMPS CAPACITY LB./HR.	HOTWELL PUMPS CAPACITY % COND. CAP.	HOTWELL PUMPS HEAD FT.	HOTWELL PUMPS DRIVE	VACUUM PUMPS NO.	VACUUM PUMPS TYPE	VACUUM PUMPS CAPACITY PER UNIT C.F.M.	VACUUM PUMPS CAPACITY PER UNIT PRES. IN. HG.	VACUUM PUMPS CAPACITY PER UNIT TEMP °F.	STM. CONSUMP/UNIT LB./HR.	STM. CONSUMP/UNIT PRES. LB. ABS.
LAKESIDE	25,000	TRANS.	2	25,000	50,000	18	MOTOR	2	315,000	130	155	MOTOR	2	STEAM JET	40	1	79	1500	140
BAYSIDE	12,700	STEAM-TRANS.	2	12,900	25,800	15	M	2	150,000	135	92	TURB.	2	ST. JET	5.6	2	70	400	
STANTON	45,000	SHAFT GEN.	1	72,000	72000	15	M	2	450,000	125	240	M	2	ST. JET	20	1	70	2700	190
EAST RIVER	47,500	STEAM	2	45,000	90,000	14.5	COND. TURB.	2	625,000	120	135	TURB.	2	ST. JET	1-19 1-25	1	70	1350	265
MORRELL ST.	27,000	TRANS.	2	18,000	36,000	20	M	2	175,000	100	380	M	2	ST. JET	20.6	1.5	80	750	140
DES MOINES	27,600 45,000	STEAM TRAN.	2 2	17,000 25,000	34,000 50,000	30 30	M	2	325,000 475,000	162 176	180	M	2	ST. JET	26.6	1.5 1	70 70	1225 700	240 140
BUCK	54,000	TRANS.	2	32,500	65,000	21	M	2	500,000	169	192	M	2	ST. JET	190 LB.	2	95		380
WHIPPANY	17,850	TRANS.	2	7,650	15,300	18	IND. M	2	150,000	147	100	IND. M	2	ST. JET	23.3	2	70	600	290
LAUDERDALE	20,000	HOUSE GEN.	2	25,000	50,000	30	M	2	325,000	143	335	M	1	ST. JET	31	2	70	800	150
HARBOR POINT	20,000	STEAM TRANS.	2	12,5000	25,000	22	1-M 1-TURB.	2	270,000	150	100	1-M 1-TURB.	2	ST. JET	75 LB.	1	70	900	165
NECHES	35,000	SHFT. GEN.	2	26,000	44,000		M	2	300,000	143		M	2	ST. JET	38.25	1	70	1345	200
KIPS BAY	—	—	—	—	—	—	NO		CONDENSING			EQUIPMENT	—	—	—	—	—	—	—
BEACON ST.	—	—	—	—	—	—	NO		CONDENSING			EQUIPMENT	—	—	—	—	—	—	—
MINNEQUA	15,000 4000	TRANS.	1	12,000	12,000	40	GRAVITY M	2 2	100,000 45,000	111 112	65 65	M M	2 2	ST. JET					
MASSILLON	14,400 6,400	TRANS.	1 1	16,100 7,000	16,100 7,000	45 50	DUAL TURB.	2 2	167,000 70,000	126 127	86 86	TURB. TURB.	2 2	ST. JET	20 11	2 2	70 70		
THREE RIVERS	—	—	—	—	NEW	ADDITION			BOILER PLANT ONLY				—	—	—	—	—	—	—

pass condensers of 20,000 sq. ft. each, supplied with 150,000 g.p.m. of water by two pumps piped so that the flow may be reversed.

The 208,000-kw. State Line turbine will have eight 22,000-sq. ft. condensers arranged as shown in Fig. 2. They are also of the single-pass vertical type with a total condensing capacity of 1,600,000 lb. of steam per hour when supplied with 360,000 g.p.m. of condensing water by four vertical pumps.

Two other notable condensers being completed are the 70,520-sq. ft. two-pass vertical units for the 91,500-kw. unit at Crawford Avenue and the 62,500-sq. ft., two-pass one for the 41,250-kw. turbine for Colfax. The latter will condense 412,000 lb. of steam per hour, using 72,500 g.p.m. of circulating water.

Surface per Kilowatt Being Decreased

There has been a marked reduction in the ratio of condensing surface per kilowatt. This has been brought

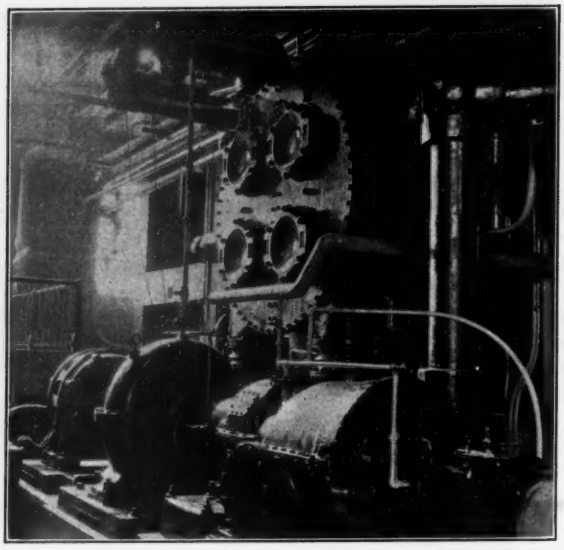


FIG. 3. MODERN APPLICATION OF DUAL DRIVE TO A CIRCULATING PUMP INSTALLED AT MASON CITY, IA.

about by improved design, steam extraction from the turbine and improved turbine water rates. Stanton, with 0.734, East River with 0.75, and Lauderdale with 0.8 are among the lowest. These, however, all have external air coolers, so that the values are not directly comparable with figures of past years where internal air cooling sections sometimes amounted to as much as 25 per cent of the total surface. External air coolers are becoming of increased importance. The ones supplied with the 45,000-sq. ft. condensers at East River have a surface of 2500 sq. ft.

Steam flow per sq. ft. of condensing surface is, of course, increasing, the highest of the stations tabulated being 11.55 lb. per sq. ft. for East River, closely followed by 11.33 for Lauderdale, 9.72 for Lakeside and 9.7 for Stanton.

Expansion joints are being used for most of the larger vertical and horizontal units. Improvements have been made in the reheating deaerating hotwells, but they are not being as widely adopted as predicted when first introduced. Divided water boxes are popular, but many of the larger units are constructed without this feature, dependence in many of the single-pass condensers being placed in the flow reversal. Water velocities through the tubes and the steam ratio remain about the same as they were last year, averaging between 6 and 7 ft. per second and 90 to 110 respectively.

Brass, muntz and admiralty metal tubes, packed with fibre, corset lace, metallic packings or rolled in the tube sheet, all appear to be about equally popular. Most of the tubes are 1-in. o.d., 18-B.W.G., although some of the single-pass condensers have ¾, ⅞ and 1-in. tubes graduated so as to give better steam distribution. Rubber plugs are almost universally used for tube cleaning and, although they are not entirely satisfactory, nothing has yet appeared which gives a more satisfactory solution of the problem.

Condenser auxiliaries are practically all motor-driven in the recent stations, although a few furnish one steam-driven unit or provide dual drive. Twenty-three hundred volt motors, arranged for across-the-line starting, are used for practically all motors above 35 or 40 hp. Figure 3 shows a modern dual drive circulating pump installed last year in the Mason City station. Where duplicate sources of electric current are not available, this drive is popular in that it gives reliability, at the same time allowing advantage to be taken of the more efficient motor drive. East River is unique in that they still use motor-turbine drive for the essential auxiliaries.

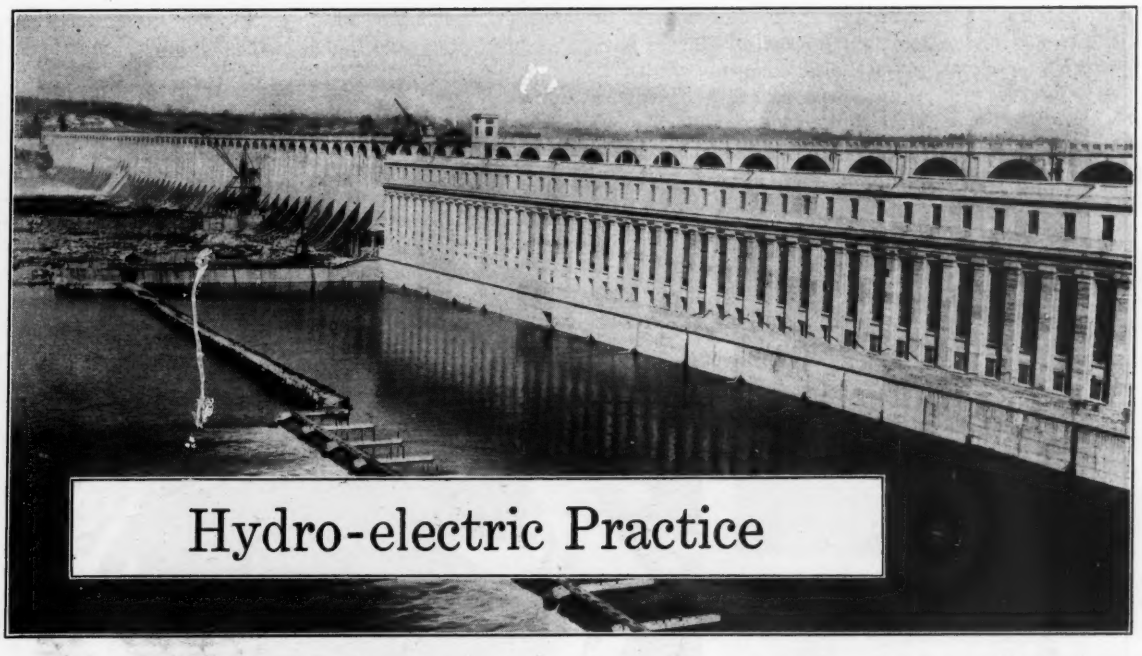
As now used, the electric drive is efficient and reliable and it is probable that in most cases a station using electrically-driven auxiliaries will show on the average a better thermal efficiency and a lower cost per unit of output, including fixed charges, than if steam-driven auxiliaries were used.

Duplicate circulating and hotwell pumps are standard practice unless the condensers are arranged to take their supply from and discharge into a common tunnel as at Stanton. The vertical circulating pumps at Crawford are a new development. They have a high efficiency at low head and may be located submerged in a pit so as to be primed at all times and eliminate suction and discharge priming lines.

Steam jet vacuum pumps are universally used in spite of the fact that they are not quite as economical to operate as the hydraulic or reciprocating units. Their maintenance is low and, most important, they take little space and may be located anywhere in reason, an extremely important item where several heaters and much piping are arranged in close proximity to the turbine. At Bayside they are on the turbine floor.

Many opinions still exist in regard to the best source of electric power for auxiliaries. On account of the higher efficiency of the main unit there has been a tendency to put all the station load on these machines. Not so many house turbine generators are being installed, although the shaft house generator which is in tandem with and direct connected to the main generator shaft is gaining in favor and is extensively used.

The Accident Prevention Committee of the N. E. L. A., 29 W. 39th St., New York City, in a recent report tells how to set up an accident prevention organization.



Hydro-electric Practice

Tendencies in Hydraulic Power Development

GREATER KNOWLEDGE OF COST AND OPERATION ECONOMY IS NECESSARY IN THE AVERAGE HYDRAULIC POWER PLANT. BY L. F. HARZA*

HYDROELECTRIC generation of power has always held a great amount of economic attractiveness. This economic attractiveness of hydraulic power development has, however, within recent years been progressively encroached upon by two principal factors: first, the ever decreasing fuel consumption per kilowatt-hour in connection with steam generation; and second, the fact that the best or most accessible hydroelectric power sites were naturally developed first and as time goes on the projects of lesser and lesser merit, or remote location, come up for consideration. This is tending to stimulate a more careful consideration of operating principles.

Most hydraulic projects were formerly and many are now operated in a very careless manner. Because of the fact that coal is paid for in cash directly in proportion to the quantity used, it is customary for the steam power plant operator to watch very carefully every phase of his power production, in order to reduce his fuel consumption to a minimum per kilowatt-hour.

On the other hand, the average hydraulic power plant, even today, is operated without any knowledge of the resulting economy and without the realization that hydraulic power plant operation deserves almost as much care and scrutiny to obtain best results as does a steam power plant. Care is generally exercised in the purchase of machinery, in order to obtain water wheels of best efficiency, as also generators, but after doing so, the average hydraulic power plant is allowed practically to operate itself. This condition doubtless arises largely because water is not paid for at a definite measurable rate per unit of quantity.

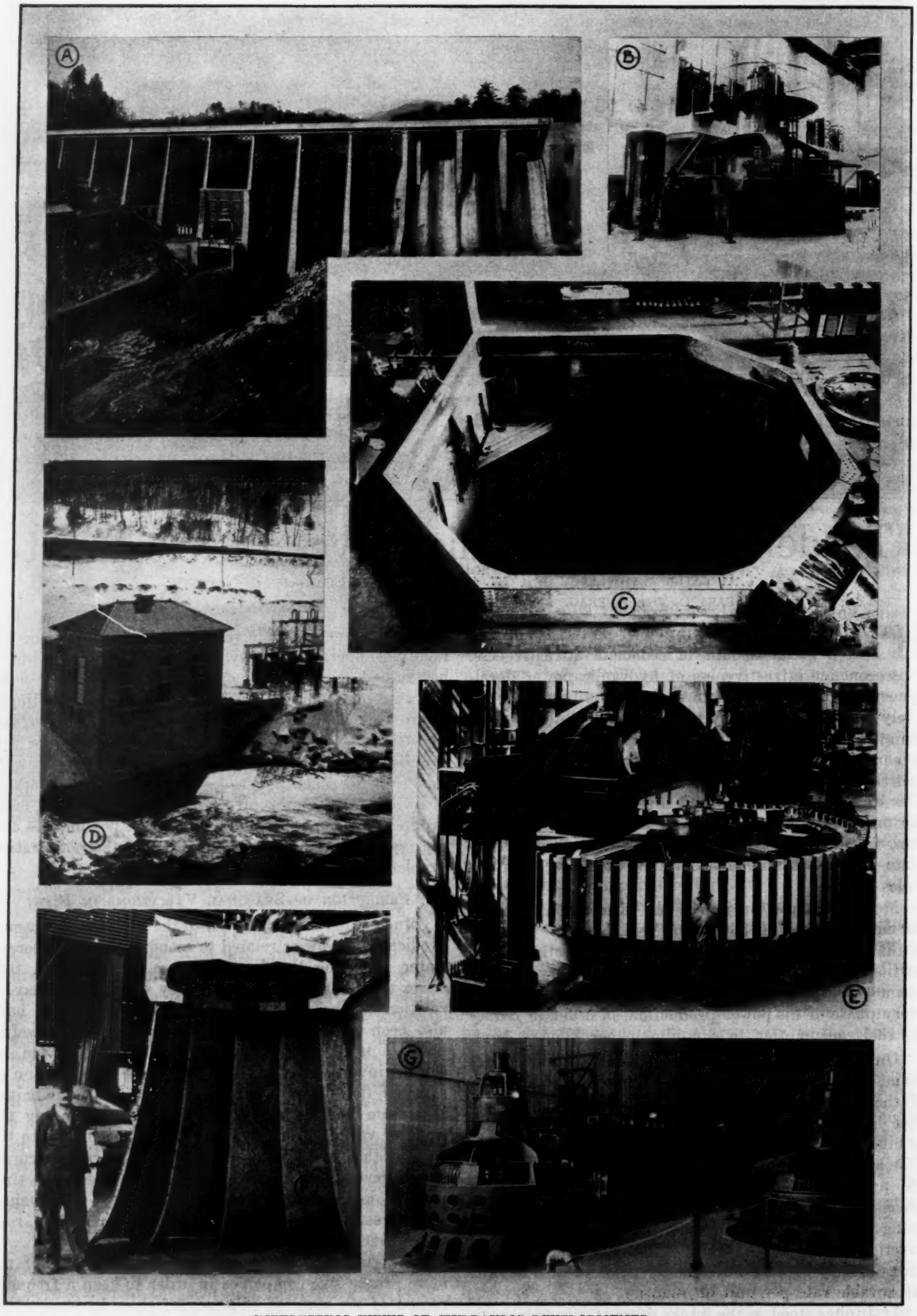
If Jupiter stood at the intake gates of a hydroelectric plant, with a cash register, and required payment in advance for every cubic foot of water entering the intake, the operation of hydraulic power plants would be studied with much more care and they would be operated much more scientifically, with correspondingly improved output. Unfortunately, water seems to cost so little that it is difficult for the executives, or hydraulic plant operators, to adjust themselves to the same careful, scientific study which the steam operator is accustomed to applying; however, a few of the more progressive companies have realized the possibilities and are applying scientific principles to their operating problem.

PREDICTION OF SEASONAL VARIATIONS IN FLOW

Much study is being given to the problem of seasonal prediction of flow as related to economical use of storage water. On the Pacific coast there is indication that ocean temperatures, as reported by ships at sea, have a relation to the seasonal rainfall. Snow surveys have also been undertaken with varying degrees of usefulness. A large amount of study has also been given, by certain investigators to the possibilities of prediction of seasonal flow by applying pre-determined periodicities in stream flow or rainfall; that is, by extending the cycle of variation of the stream flow or runoff into the future, this cycle being determined by past records. These developments are in addition to the short time predictions of a few hours or a few days in advance, which result from daily reports of stream and rain gages over the watershed.

Periodic tests are being resorted to by some of the more progressive companies in order to keep a frequent record of the state of efficiency of their hydraulic turbines and to permit repairs and replacements as soon as the loss of efficiency justifies. These tests tend to reveal the condition of the clearances between turbine runner

*Consulting engineer, Chicago, Ill.



INTERESTING VIEWS OF HYDRAULIC DEVELOPMENTS

A. The Lake Lure Dam. B. One of the 13,500-kv.a. generators at the Melones plant. C. A testing pit built at the G. E. Co. for running speed tests on the rotors of water wheel generators. D. The Sherman Creek hydro plant. E. Large steel spider, weighing 175,000 lb., for the Conowingo generators, being machined at the W. Elec. & Mfg. Co. F. One of 3 sections of 60,000-hp. runners for one of the Conowingo turbines, at the Allis-Chalmers Mfg. Co. G. An interior view of the Lake Lure station.

and casing, also the condition of the runner as to erosion and pitting, rubbing on the casing, etc.

Steam and Hydro Plant Operation Must Be Considered as a Unit

As most hydraulic powers feed into a system supplied by combined hydraulic and steam sources, it is absolutely necessary for maximum economy of both steam and water to place the operation of the system under a single head or load dispatcher, with absolute authority to dictate to each generating plant on the system just how it shall be operated under all conditions of load and stream flow, in order best to economize both water and coal for the system as a whole. This supervision must not only take the form of the establishment of general rules of procedure but must consist of continuous supervision by a load dispatcher in constant touch, by telephone, with all generating plants in the system. He must keep plotted before him at all times the system load curves up to the moment; he must know the conditions of flow at each hydraulic power plant on the system, units in service and ready for service; he must obtain information as far in advance as possible of possible rises in each river at each power plant, by means of rainfall records and gage readings wired or telephoned to him from selected points on the watershed; he must be thoroughly familiar with all of the important contracts for sale of power and especially with contracts for interchange of service with neighboring companies; he must, by scientific study and analysis of the situation, constantly exercise his judgment as to the conditions under which it is best to store water and use steam, or to draw down on the storage in reservoirs in order to create storage capacities for accumulating an impending flood or excess flow in the river; he must know under what conditions it is most economical to accept surplus power from a neighboring company under an existing interchange contract and conserve water on his own system, or under what condition it is best to operate the steam unit as nearly loaded as possible in the interest of steam economy, allowing the hydros to operate at variable load and reduced efficiency with sacrifice of water economy, as compared with allowing the steam units to take the fluctuation with corresponding sacrifice in steam economy. The operation of a combined steam and hydro system is a highly scientific problem, requiring a load dispatcher of high grade scientific knowledge and ability continuously in communication with the entire system.

Relative Costs of Steam and Hydro Plants

Generating capacity for heads greater than 25 ft., that is to say, the generating machinery and appurtenant structures, exclusive of dam, overflowed land and similar fixed costs is usually cheaper in hydro than in steam. Thus, roughly, having the dam and fixed costs completed in a hydro project of 100-ft. head, the generating capacity can be installed at about one-half the cost of steam generating capacity. For this reason, it has been found most economical, where a hydro plant is provided with sufficient storage, to multiply its capacity for peak load service, permitting the steam stations to run on base load, except, of course, when the stream is supplying excess water in flood season, at which time the hydraulic plant supplies all of the power it can generate and the steam plant the remainder. The hydraulic unit offers still farther advantage for peak load service, because of the relative rapidity with which it can be brought into service as the load grows, as compared with the steam unit. Furthermore, the hydraulic unit is consuming its fuel only for the actual time of operation, whereas the steam unit for short time peak load operation consumes fuel for a considerable period, while boiler capacity is being put in service and cooled off again afterward.

The advantages of hydraulic power for peak load service are of such importance that it is not probable that it will soon, if ever, be displaced by steam for this class of service, where projects exist having sufficient storage and head and otherwise adapted to peak load operation primarily.

Use of Propeller Type Turbines

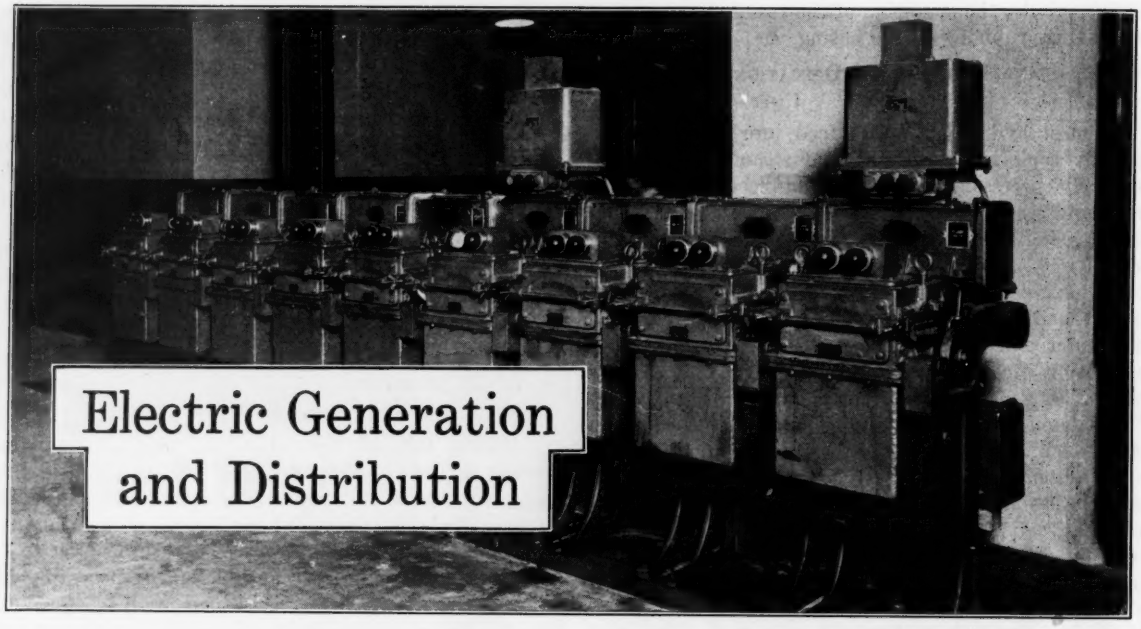
During the last few years the pressure to reduce cost in hydro developments has led to a considerable popularity of the propeller type turbine runner. This type of turbine, because of high speed, has resulted in lower machinery cost, a feature often appealing to the executives more vitally than subsequent operating efficiency. The propeller runner has nearly as good full load efficiency, although considerably lower part load efficiency. Its power holds up better under reduced head. The propeller runner is usually justified by the reduced initial cost where units can be run at or near full load, or where head reduction is frequent and long continued.

To overcome the objection of low part load efficiencies of the propeller type runner, and still further to hold up the power under low head conditions, movable blades have been developed and installed in several projects. Thus far it is necessary to shut down the unit in order to readjust the angle of the blade. This is not generally practicable for the frequent changes in load occurring throughout the daily load cycle, but it is quite possible to accommodate the machine to more efficient operation during periods of flood discharge, and consequently low operating head. It is to be hoped that this type of equipment can be improved to the point where adjustment of blade angle can be made while in operation.

By tests on model hydraulic structures, it has been possible to make great improvements in many of the features of hydroelectric projects. For example, in the last ten or fifteen years draft tubes have very greatly improved and several types have been brought from an efficiency of zero up to an efficiency of about 75 per cent. Models have been applied to improve the shape of scroll cases and ice diversion walls, to devise schemes of aprons to prevent erosion at the toe of dams and for many similar purposes with great success. It is believed that the value of models in hydraulic design for any purpose cannot be too greatly emphasized, either for water power or other river problems.

One new mechanical development in the art, within the past year, has been that of a Kingsbury bearing having a bearing surface of hemispherical or spherical segment form, instead of flat disk, to serve as a combined guide and thrust bearing.

In general, the past year has been characterized by intensive study and improvement in details of previous practice in design and operation of hydro stations, rather than by any radical or evolutionary developments.



Trends in Electrical Design of Power Plants

BUS AND SWITCH HOUSE DESIGN, GENERATOR PRACTICE, TRANSFORMER AND CIRCUIT BREAKER DEVELOPMENTS AND STRUCTURAL DESIGN. BY R. E. ARGERSINGER*

IT IS PROBABLY true that aside from the measures taken to provide for increase in capacity, the general features of electrical design of our power stations have not changed as rapidly in the last few years as the mechanical layout. The introduction of isolated phase construction, and perhaps the electric drive for auxiliaries, have been the major developments but modifications have been made in many details, the majority of which have tended to increase the complexity of switch house arrangement.

Disregarding for the moment isolated phase construction, we have installed combinations of double buses with and without ring connections with transfer buses, group buses and testing buses when frequently a properly constructed arrangement of two buses should be sufficient.

Some signs are appearing of a reaction against these layouts to which we have resorted in an effort to minimize damage to service and equipment resulting from disturbances either on the distribution system or in the station. The root of the difficulty is in the unreliability of the oil circuit breakers. If, for instance, existing breakers could be depended on to perform their functions as consistently as do standard squirrel cage induction motors, switch house costs could be materially reduced. Some designers are adopting outdoor equipment for 13,200-v. switching in an effort to lower building costs and, at the same time, minimize the disastrous effects of circuit breaker failures. Whether or not this practice becomes generally accepted, the important subject on which attention should be concentrated is the improvement of the circuit breaker.

The use of isolated phase construction is not universally approved and many engineers do not consider that the advantages obtained are worth the complications involved. All will agree that a liberal factor of safety in insulation to ground is advisable and considerable improvement can be made in our switch gear arrangements in this respect. In some recent installations the buses and connections have been completely insulated with varnished cambric.

The provisions for supplying power to station auxiliaries are various; however, there seems to be rather a definite trend toward the use of an alternating current shaft end generator on the main units to be used for the principal auxiliary power source, using the main station bus as a reserve supply. This naturally results in a unit system, each auxiliary unit bus being fed from the shaft end generator and supplying in turn the major auxiliaries for the main generator units. Means are provided for automatically connecting the unit bus to the main reserve bus in case of failure of the generator normally feeding the unit bus, the reserve bus being supplied through transformers from the main station buses.

A somewhat similar scheme embodies the use of a transformer bank connected to the leads of each main generator and feeding the auxiliary unit bus in place of the shaft end generator. For relay service connections may be made to the main bus but for best results there should be a separate house generator. The first scheme gives greater independence from the main bus which is the desirable thing but the second is probably somewhat more economical.

The use of electric drive has permitted greater flexibility of operation of auxiliaries, particularly in connection with automatic combustion control. It has also permitted greater ease of operation by its ready adaptability to remote control and to automatic restarting in

*Chief Electrical Engineer, Stone & Webster, Inc.

case of shutdown. Further development can be expected along this line in the way of simpler variable speed alternating current motors, better protection of motors against dust and moisture, and more substantial as well as simpler control devices.

Generators

There has been a definite tendency recently to use larger steam turbine-driven single unit generators and to considerably increase the rated voltage. Machines are now being built for 22,000 v. and at least one single-shaft generator, rated at 160,000 kw., is under construction. Experience with 22,000-v. generators is as yet very limited, but there appear to be no serious difficulties in their construction. For systems where an intermediate distribution voltage is desired, they would seem to have a very definite use.

The double winding generator recently developed by one manufacturer is also of considerable interest. This generator is constructed similarly to any other except that the stator winding is connected to make two entirely separate three-phase windings, each of half the total rating of the machine. It appears that such a generator will be particularly useful in stations of large capacity where each winding may feed different bus sections. Connected in this manner, the generator also serves to take the place of a bus section reactor.

Excitation

Considerable attention has been given to high speed excitation systems in an endeavor to maintain bus voltage at times of system disturbance, and several arrangements of equipment have been produced which should materially improve the stability of our interconnected networks. However, they have the disadvantage of adding still further to the duty of the oil circuit breaker.

Transformers

Much study and research work is under way on the design of extra high voltage transformers to secure a greater factor of safety against breakdown from lightning disturbances. This has resulted in some unusual designs, the performance of which will be awaited with interest. At the present time information is not conclusive as to voltages which can be reasonably expected on a transformer winding under various transmission line and station conditions and there is a very definite field for study in this connection.

Considerable thought has been given to the standardization of transformer voltages and certain tentative ratings have been set up for further consideration, based on the use of different voltage ratings for step-up and step-down transformers. It would seem that such a plan would not result in any considerable simplification of transformer ratings and whether or not it will be successful remains to be seen.

The use of forced air cooling for large transformers seems to have merit under certain circumstances, although in general any means of forced air or water cooling should be carefully scrutinized from the standpoint of operating costs, since in most cases it will be found that the fixed and operating charges on cooling equipment are sufficient to make up any apparent difference in initial cost.

Oil Circuit Breakers

Considerable research work has been done on new types of circuit breakers, which will interrupt the circuit in a vacuum, and also with breakers having a greatly increased speed of operation. So far results have not progressed beyond the laboratory stage but it seems almost certain that some radical change in design must be made in order to secure satisfactory circuit breakers for high voltage systems with their constantly increasing demands for greater rupturing capacity.

Some study has been given to the voltage surges occurring in distribution systems as affecting the equipment. It is apparent that flashovers occasionally occur in our power stations at voltages much beyond anything that would usually be expected. These may occur not only from a high surge potential but also because of a decreased flashover value on some given piece of equipment, due to the surrounding structural conditions. Experience has shown that a circuit breaker will withstand a much higher flashover value under factory test than when finally installed in a compartment in the station with all of its connections and mechanism attached. This is probably due partly to the field distortion caused by metal structures surrounding the breaker and partly to ionized air in the more or less tightly closed compartment. This question needs further study and possibly a greater factor of safety in our flashover values for circuit breakers.

Enclosed switch gear seems to be growing in popularity. The older forms of compound-filled equipment, as manufactured in England, are being introduced in this country and recently equipment has been produced which is oil-filled rather than compound-filled and suitable for outdoor use. This is a very interesting development and its performance will be carefully watched.

Switchboards

With the increasing size of power stations the dimensions of the main control boards have also grown until the problem of supervision of the large board is a serious one. Designers have, therefore, given considerable thought to the development of miniature control boards of various types, in some cases using the principle of supervisory control and in others merely reducing the size of instruments and other fittings. It appears that there is a very definite field for a type of control board using small control devices which may be assembled on much smaller panels than the usual structures so that the resulting board will be reduced possibly to dimensions such as those of an ordinary desk. Some boards have already been built of this type and further development may be expected.

Carbon break circuit breaker switchboards for low voltage station service are being introduced and apparently with promising results. Some development in equipment and housings is still necessary to produce an altogether satisfactory arrangement.

Conductors and Supports

Some difficulties have been experienced with 15,000-v. braided cable in fibre ducts as installed in power stations where corona has apparently caused deterioration of the insulation, particularly at duct entrances. It has been found that the use of asbestos flame-proof braid

under such circumstances has practically prevented damage. In other cases of trouble from corona on copper bars passing through bushings, the difficulty has been materially lessened by coating the inner surface of the bushing with a conducting compound and connecting the bar to the coated surface. These expedients will be increasingly important in the design of stations using generator voltages higher than 15,000.

Structural Design

There is still room for improvement in the details of structural cells and barriers in the switch house. Where to use and where not to use reinforcing, under what circumstances the reinforcing should be continuous and where there should be definite breaks in the metallic path, are all questions that merit careful study. The use of brick construction has certain advantages but is inconvenient for concealing conduit and possibly the conduit itself may cause as much trouble as reinforcing steel.

These and many other questions are still to be answered and notwithstanding the duplication of circuits and the addition of protective devices in our electrical layouts, troubles still occur. Perhaps it is time to make a definite attempt to simplify our designs even though we omit some of the things we now regard as necessities.

Electric Generators Reach 100,000-Kw. Mark

Construction of Extremely High Capacity Generators and Adoption of Higher Voltages Mark Progress in Electrical Design

WHILE THE GENERAL form of the turbo alternator has undergone no radical changes during the past few years it has been subjected to constant refinement. With the possible exception of the static transformer, the turbo alternator is perhaps the most highly perfected piece of equipment in the power station. In capacities, the trend has been steadily upward. From the largest units, 30,000 and 35,000 kw. capacity, five or six years ago, they have grown to sizes of 90,000 and 100,000 kw. at present.

A number of extremely large units are now in course of construction. Notable among these are the 104,000 kw. Westinghouse unit for the Crawford Avenue Station of the Commonwealth Edison Co., the 108,700 kw. Westinghouse unit for the Hudson Ave. Station of the Brooklyn Edison Co., the 160,000 kw. American Brown Boveri unit for the Hell Gate Power Station of the United Electric Light and Power Co., the 165,000 kw. General Electric machine for the Philo Station of the Ohio Power Co. and the 208,000-kw. General Electric unit for the State Line Power Station of the Commonwealth Edison Co.

These sizes, of course, refer to the turbines and since in most cases the turbines are triple or compound units consisting of a number of separate elements each connected to its respective generator, the alternators are of considerably smaller capacity than the rating for the complete unit. The largest single shaft generator unit on record will be the 94,000 kw. 1500 r.p.m. unit installed at the Long Beach Station No. 3 of the Southern California Edison Co. In this case the turbine is direct connected to a 100,000-kv.a., 16,500-v., 50-cycle generator, with a 5000-kv.a. auxiliary generator and a 60-kw. exciter for the auxiliary generator on the same shaft.

In the stations considered in this survey the capacities of the generators, it will be noted, range between 3750 and 60,000 kw. These do not approach in size some of the large units just mentioned but this list is representative of the sizes being installed throughout the country in the average central station and large industrial plants. The 3750-kv.a. machines at Beacon St. are smaller than usually found in central stations of consequence but Beacon St. is a central heating plant and these turbines are installed to serve as reducing valves, the exhaust steam being delivered to the heating mains.

Speeds and Frequencies

With few exceptions generator speeds in America are 1800 r.p.m. This, of course, is due to our almost universal use of 60-cycle frequency. Where 25-cycle systems are used, the usual speed of the generators is 1500 r.p.m. In considering the question of the most desirable speed and frequency it has been pointed out that a speed higher than 1800 r.p.m. would be desirable but with 60 cycles, the next higher speed of 3600 r.p.m. is too high for machines of large capacity. For small machines, the speed of 3600 r.p.m. used at Beacon Street station is common.

Generator Voltages to Be Higher

Generator voltages in all of the larger stations are in the neighborhood of 13,000 v. No exact voltage is standard but the values vary between 11,000 and 14,000 depending upon individual requirements. The average of all the stations in the accompanying tabulation, having voltages over 10,000 is 12,927. For small units voltages of 6600 and 4800 are common.

As pointed out in the preceding article on tendencies in the electrical design of power plants, there is a distinct tendency toward the use of higher generator voltages. Higher voltages are desirable, particularly in large capacity, since they permit the use of copper of smaller cross section. Until the recent development of extremely large size generators, the customary voltage of around 13,000 was consistent with the most economical sizes of copper used in the machines. With the increases in size of generators which today have reached a maximum of 100,000 kw., an increase above the customary 13,000 v. is desirable.

Several machines using higher voltages are under construction, among which is a 100,000-kv.a. machine for 16,500 v. operation and a single shaft unit of 61,765 kv.a. that will operate at 22,000 v. The 208,000-kw. units to be installed at State Line Plant are also wound for 22,000 v.

Developments in Generator Construction

In connection with the manufacture, shipment, and installation of the large alternators now being produced, there has been an extension of the use of the skeleton frame construction for stators, and also in speeds of 1500 and 1800 r.p.m. The old type of construction made a final unit which was necessarily heavy and usually too large for shipment on the railways.

With the skeleton frame construction, the frame is strong enough to support itself during machining and assembly. Special bolted-on plates and trunnions for each frame facilitate handling during assembly at the works, loading and unloading during shipment, and final erection at the destination. The over-all dimensions of the frame, assembled for shipment, allow the completely assembled unit to be shipped direct to its destination. The ventilation requirements are cared for by an external superstructure of sheet metal applied at the destination. With this construction 1800 r.p.m. turbine generators up to 75,000 kv.a. can be built and wound at the works and shipped complete. As a result of this, large turbine generators can be tested at the works, the freight charges are reduced, handling during assembly, shipment and erection is made easier, closer inspection is made possible during manufacture, and for connection. For these reasons, types of half coil construction are being used in which the strands in each conductor are transposed in the slot portion. One construction provides a complete transposition in the slot of all the strands in the conductor as one group while in another construction the strands are arranged in small groups and the strands of each group are transposed internally while the groups are transposed at the ends. These constructions permit the use of coils which are relatively easy to handle and assemble and yet make the eddy current losses as low as possible.

Voltage Regulation

Manual regulation of generator voltage predominates in nearly all of the large stations supplying metropolitan areas. This is borne out in the accompanying tabulation. Such stations as Whippany, Stanton and

ELECTRIC GENERATOR PRACTICE

NAME OF STATION	MAIN GENERATING UNITS								HOUSE SUPPLY			EXCITATION		
	TYPE	CAPACITY	SPEED	PHASE + FREQ.	VOLTAGE	VOLTAGE REG.	COOLING TYPE SYS.	COOLING TYPE COOLER	METHOD	ALTERNATIVE METHOD	VOLTAGE	TYPE EXCITERS USED NORMAL	TYPE EXCITERS USED EMERGCY	VOLTAGE
LAKESIDE	T.A.	1-7,000 1-30,000	3600 1800	3ϕ-60~	13,800	MANUAL	CLOSED OPEN	SPRAY	TRANSFORMERS	HOUSE TURBINE GENERATORS	440	DIR. CONN.		240 V.
BAYSIDE	T.A.	2-10,000	1800	3ϕ-60~	14,000	MANUAL	CLOSED	U-FIN	ESSENTIAL AUX. BY STEAM TURB.-TRANSF.	TRANSFORMERS FROM TRANSMISSION LINES	2300 V.	TURB. OR DUAL DRIVE SET	MOTOR DRIVEN UNIT	275 V.
STANTON	T.A.	2-45,000	1800	3ϕ-60~	11,000	AUTOM.	CLOSED	FIN TUBE	AUX. SHAFT GEN.	TRANSFORMERS FROM OUTSIDE LINES	2300 V.	SHAFT TYPE		250 V.
EAST RIVER	T.A.	60,000	1500	3ϕ 25~	11,400	MANUAL	CLOSED	SPECIAL FIN TUBE	FROM MAIN BUSES THRU. 8000 KV.A. TRANS.	FROM OTHER STATIONS D.C. FROM BATTERIES	2300 V. A.C. 230 V. D.C.	SHAFT TYPE		250 V.
MORRELL ST.	T.A.	3-20,000	1800	3ϕ-60~	13,200	MANUAL	CLOSED	FIN TUBE	TRANSFORMER	1000 KW. TURBO-GEN. 250 KW. M-G SET	550 V.	SHAFT TYPE	MOTOR-GEN. SET	250 V.
DES MOINES	T.A.	1-25,000 1-35,000	1800	3ϕ-60~	13,800	MANUAL	CLOSED	FIN TUBE	HOUSE TURB.	TRANS.	2300-440	SHAFT TYPE		250 V.
BUCK	T.A.	2-35,000	1800	3ϕ-60~	13,200		CLOSED	FIN TUBE	HOUSE TURBO-GEN.	TRANSFORMERS	2300 V.	SHAFT TYPE	MOTOR-GEN. SET	250 V.
WHIPPANY	T.A.	2-10,000	1800	3ϕ-60~	6,600	SEPARATE EXCITER REG.	CLOSED	FIN TUBE	TRANSFORMERS	AUX. TURBO-GEN.	440 V.	SHAFT TYPE	MOTOR-GEN. SET	250 V.
LAUDERDALE	T.A.	31,250	1800	3ϕ-60~	13,800	AUTOM.	CLOSED	FIN TUBE	1800 KV.A. 1 STAGE - NON COND. HOUSE TURBO-GEN.	TRANS. FROM MAIN BUS	2300 V.	SHAFT TYPE	200 KW. MOTOR DRIVE	250 V.
HARBOR POINT	T.A.	15,000	1800	3ϕ-60~	13,800	AUTOM.	OPEN	NONE	TRANS.		440 V.	150 KW. SHAFT TYPE	200 KW. TURB. DRIVE	250 V.
NECHES	T.A.	20,000 KW.	1800	3ϕ-60~	13,200		CLOSED	U-FIN SURFACE	1000 KW. AUX. GEN DIR. CONN. TO MAIN SHAFT	TRANS. FROM MAIN BUS	2300 V.	TURB. + MOTOR	MOTOR	250 V.
KIPS BAY	CENTRAL HEATING PLANT. ELECTRICITY FOR HOUSE SERVICE ONLY								2-300 KW. TURBO-GEN.	NONE	2300 V.	SHAFT TYPE	NONE	250 V.
BEACON ST.	T.A.	3750 KV.A.*	3600	3ϕ 60~	4800	MANUAL	OPEN USING MECH. TYPE AIR FILTERS		GEARED TURBO-GEN. 2400 KW.		300 V. D.C.	SHAFT TYPE	NONE	250 V.
MINNEQUA	T.A.	3-10,000	1800	3ϕ-60~	6600	REGULATOR	CLOSED	SURFACE	DUAL DRIVE D.C. GENERATORS	DUAL DRIVE GEN. - POWER CO. SERVICE	250 V. D.C.	TURB.	TURB.	250 V.
MASSILLON	T.A.	1-12,500	1800	3ϕ 60~	11,000		CLOSED	FIN TUBE	MAIN UNIT THRU TRANS.	SPARE TRANS.	2300	SHAFT TYPE		250 V.
THREE RIVER	BOILER PLANT ONLY. ELECTRICITY USED IS GENERATED BY OUTSIDE HYDRO ELECTRIC PLANTS											*		

T.A = TURBO-ALTERNATOR.
* - ONLY PART OF STEAM OUTPUT IS PASSED THROUGH THIS TURBINE. PLANT IS PRINCIPALLY A LINE STEAM HEATING PLANT

there is less confusion to the purchaser when shipment is made.

There has been considerable activity in developing new types of stator windings, involving transposition of strands in each conductor, and transpositions at the heads of the machine or in the connections. The use of half coils is becoming more common practice among the different manufacturers. It has been found that the use of continuous coils and the control of the eddy current loss factor by transposing the strands of each conductor at one end of the machine is satisfactory up to about 50,000 kv.a. In larger capacity machines, coil length and weight are so great that it is difficult to handle the coils during manufacture and assembly. This has favored the use of half coils especially in view of the facility with which damaged coils can be replaced in the machine.

In order to make the eddy current loss in half coils as low as in continuous coils, either elaborate transposition of the strands at each end of the machine or transposition of the strands inside the armature core is necessary. Complete external transposition of half coils is undesirable because of the large space required

Lauderdale which feed directly through transformers into transmission lines have automatic voltage regulation. Stations such as Lakeside, East River and Morrell St., which supply city areas, have manual regulation. In the latter type of station, each feeder or group of feeders is equipped with a voltage regulator which controls the voltage at the load regardless of slight fluctuations of the generator voltage.

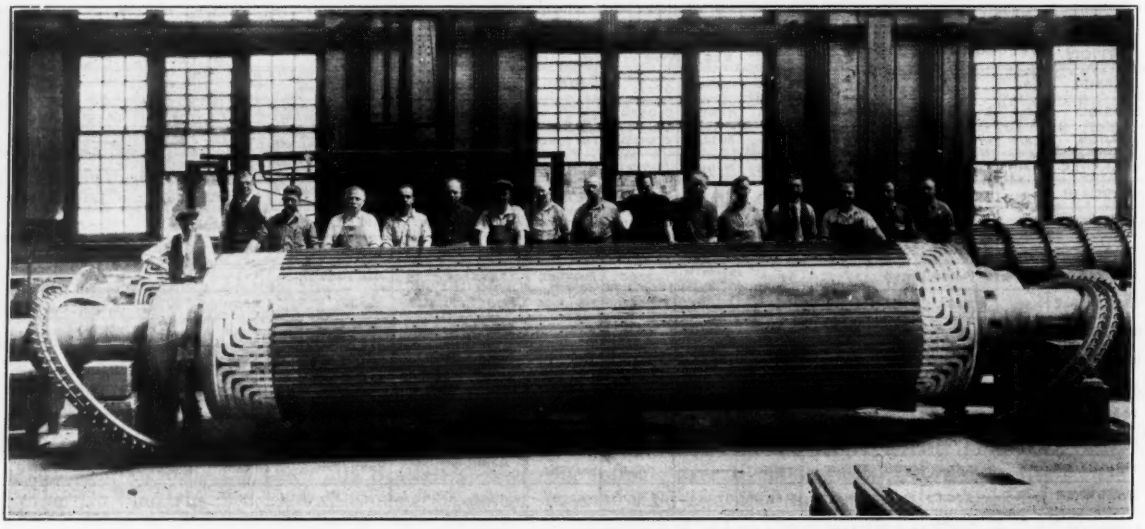
Ventilation and Cooling

Generator capacities have reached a point where it becomes absolutely essential to employ some means of forced ventilation to carry away the heat produced due to the copper and iron losses, and it is almost universal practice to use the closed system of ventilation with surface air coolers. In the machines considered in this survey, the closed system is used in all cases but two.

The introduction of the enclosed machine used in conjunction with the closed system of ventilation, has resulted in the installation of a number of CO_2 fire extinguishing systems. Where this protection is used, the CO_2 is injected into the air intake duct and a predetermined concentration is maintained until the machine comes to a standstill.

In connection with the closed system of ventilation, the possibility of using an inert gas continuously has been suggested but the predicted advantages have not been considered sufficient to warrant its introduction. The use of hydrogen, however, promises many advantages and considerable experimenting has been done on this question by the General Electric Co. Hydrogen will conduct seven times as much heat as will air for the same temperature gradient and is about 30 per cent more effective in wiping heat away from the surfaces to be cooled. For this reason a hydrogen cooled machine can be run at much lower copper temperatures and still deliver the same output, or if operated at the same temperature as in air, it will deliver considerably more output. The new high pressure turbo generator at Lakeside Station has been designed so that hydrogen can be used at some future time if deemed desirable.

Whether a machine operating in hydrogen be operated at a lower temperature or the same temperature as in air, its insulation is prevented from oxidizing and will have a longer life. The same property of hydrogen which prevents slow oxidation of the insulation also prevents its rapid oxidation, or combustion. Though an internal short circuit cause an arc, no flame would result and the damaging action would stop immediately the field and armature breakers were opened. Because the mention of hydrogen suggests the possibility of an explosion, the question of this hazard has been raised. The General Electric Co., which is experimenting with hydrogen cooled generators, claims that no such danger can exist if hydrogen of commercial purity is used and air is excluded. There are several devices now available to give continuous indications of the purity of the hydrogen cooling atmosphere, and if desired these can readily be incorporated in some reliable scheme of automatic control. Considered as a whole, the possibility of converting one-third of the generator losses into useful output and of simultaneously increasing the capacity of the machine about 30 per cent, merely by the substitution of hydrogen for air promises to be an important step in the further development of the electric generator.



ROTOR OF 100,000-KV.A. ALTERNATOR UNDER CONSTRUCTION FOR THE SOUTHERN CALIFORNIA EDISON CO. THE MACHINE OF WHICH THIS IS A PART IS THE LARGEST SO FAR BUILT

Generator Winding Connections

It is usual practice with most large three-phase turbo generators to bring out the leads from both ends of all windings so that either the delta or star connection may be used. This also permits of the installation of current transformers on both ends of each lead for use with the differential system of relay protection.

Most stations with generators of large output use the Y connection since this connection possesses certain advantages over the delta connection. Small alternators as a rule operate equally satisfactory whether the Y or delta connection is used. With units of large output, however, circulatory currents tend to flow if the delta connection is used. These circulatory currents are due to the wave form being non-sinusoidal. With the Y connection such circulatory currents cannot exist.

At low loads, however, the delta connection possesses an advantage in that it makes the generator more efficient. It was this fact that led the engineers in designing the electrical features of a recent hydro-electric plant, to provide, at a slight increase in cost, an arrangement whereby the generators could be connected Y or delta at will.

When operating at ¾ load and above the generators are operated Y connected. When operating below ¾ load, by means of suitable double throw switches, the generator connection can be changed to delta, thus diminishing excitation requirements, decreasing losses, and permitting through this increase in generator efficiency an additional output of about one million kilowatt-hours per year, which would be lost if the generators were connected Y at all times.

Protection of generating equipment seems to favor some form of differential or balanced relay scheme. This gives protection from one end of a generator winding to the breaker leads for nearly all sources of trouble that may occur and yet insures the generator remaining on the system under all other operating conditions.

Switching Arrangement and Transformers

Isolated Phase Arrangement Seems to Find Favor in Most Stations. Transformer Development Keeps Pace with Increase in Generator Sizes

HIGH CAPACITY in generating units and the tendency toward the use of higher voltages has increased the necessity for improved switching and bus systems. Several systems of bus arrangement and switching methods are in use and while they serve present needs they apparently are capable of further refinement and improvement for there has been considerable discussion of them lately. The arrangements in use vary in different stations but certain fundamental principles must be observed in all of them. Reliability, of course, is of paramount importance but reliability must not be gained at the expense of flexibility. The main function of any switching system is to collect, measure, control, and distribute the generated electrical energy in expeditious manner, and anything which would tend to impair this function is to be avoided. At the same time the design must be simple so as to provide as direct a route as possible from the generator to the feeder.

Consistent with this requirement of simplicity is the present trend toward the elimination of buses and circuit breakers between the generators and the step-up transformers feeding the load in certain types of stations. Stations such as Stanton, Buck and Whippany which feed directly into high tension transmission systems are typical of this class. In these stations the generator leads are connected directly to the primaries of the step-up transformers. In the case of Whippany there are switches between the generator and transformer but at Stanton, the connection is unbroken and all switching is done on the high tension side of the transformers.

In stations supplying large metropolitan areas or having a large number of low tension transmission lines to supply there is necessity for an extensive low tension bus and switching system. Lakeside, East River, Morrell St. and Des Moines stations come under this classification as do also most industrial plants.

Two systems of bus arrangement are in general use; the grouped phase arrangement and the isolated phase system. For high voltage, high capacity systems, the isolated phase systems seems to be generally favored in this country although this point of isolated versus group phase arrangements has been the subject of considerable controversy. In the stations under consideration in this survey, the isolated, and particularly the vertical isolated phase system predominates.

With the almost universal practice of using remote controlled switches and circuit breakers has come the practice of making the switchhouse an entirely separate unit from the turbine room proper. In some cases

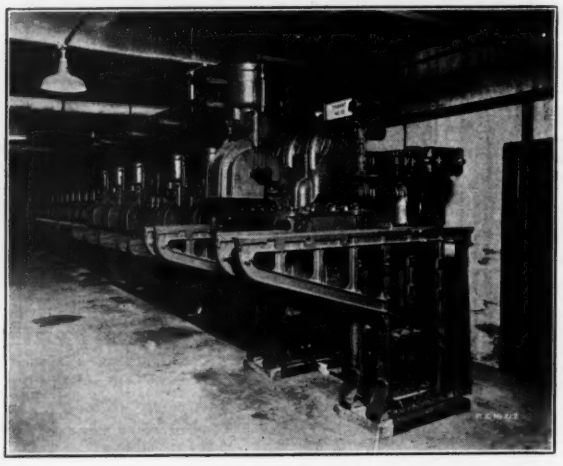
ELECTRICAL CONNECTIONS

NAME OF STATION	METHOD OF CONNECTION	SINGLE LINE DIAGRAM	SWITCHING SYSTEM: TYPE + VOLT. OF SWITCHES	SWITCHING SYSTEM: METHOD OF CONTROL	BUS SYSTEM: TYPE	BUS SYSTEM: VOLTAGE	PROTECTIVE FEATURES: REACTORS	PROTECTIVE FEATURES: RELAYS	PROTECTIVE FEATURES: GROUNDING	NOTES
LAKESIDE	GEN. TO O.C.B. TO DUPLICATE BUSES	13,200 V.	OIL C.B. 15,000 V. MOTOR OP.	REMOTE ELECT.	GROUP + ISOLATE PHASES	13,800	3% ENCLOSED TYPE ON FDR. + BUS REACTORS	DIFFERENTIAL RELAY PROTECTION ON MAIN GEN.	NEUTRAL GROUND THROUGH 30 OHM RESIST.	DISCONNECTS & COMPARTMENT DOORS OF SW. CELLS INTERLOCKED WITH O.C.B.
BAYSIDE	GEN TO OC. B. TO DUPLICATE BUSES		13 KV. INDOOR TRUCK TYPE 73 KV. OUTDOOR ALL MOTOR OP.	REMOTE ELECT.	VERT. ISOLATED PHASE	13,200 V.	†	OVERLOAD + DIRECTIONAL RELAYS. DIFFERENTIAL RELAYS ON GEN.	GEN. NEUT. SOLIDLY GROUNDED	†PROVISION FOR 13 KV. FEEDER REACTORS WHEN CAP. IS INCREASED
STANTON	GEN. DIRECT TO H.T. TRANS.		OUTDR. O.C.B. BOTH SOLENOID* MOTOR OR 73 KV.	REMOTE ELECT.	H.T. MAIN + RESERVE BUSES OUTDOOR	69.3 KV.	1 SET * BETWEEN 2-66 KV. SW. STA.	BALANCED ON FEEDERS	GEN AND H.T. TRANS. SOLID	*½% REACT. 1300 KV.A.-3000 V.
EAST RIVER	GEN. TO REAC. TO SYN. BUS THRU O.C.B. TO EITHER OF 2-11,400 V BUS.		DEAD TANK - EACH POLE ON SEP. FLOOR. 15,000 V.	MOT. OP. CENTRIF. REMOTE CONT.	VERT. ISOLAT. PH.	11,400 V.	6% 11,400 V. IN GEN. LEADS	DIFF. PROT. FOR GEN. + TRANS. BALANCED CURR. PROT. ON GEN. WINDINGS	ALL BUS INSULATORS TO SEP. GRD. BUS CONN. TO MAIN GRD. THRU CURR. TRANS.	ARE CONN. WHICH IS BUS
MORRELL ST.	GEN. TO TRANS. TO C.B. TO EITHER OR BOTH SIDES OF RING BUS		OIL C.B. CELL CONSTR. SOLND. OP. 24,000 V.	REMOTE ELECT.	VERT. 150. PH.	24,000 V.	ON TRUNK LINES + HS TRANS. 3%	DIFF. PROT. FOR GEN. + OVERLOAD ON FEEDR.	GEN. NEUT. SOLID	
DES MOINES	GEN. TO EITHER OF 2 O.C.B. TO DUPLICATE BUSES		MOTOR OP. O.C.B.	REM. CONT.	VERT. 150. PH.	13,800 V.	ON 138 KV. FEEDERS AT PRESENT	DIFF. ON GEN + TRANS. BANKS - INDUCTION + OVERCURR. ON FEEDERS	THRU 30 OHM R. ON 44 KV. - THRU 100 OHM R. ON 66 KV.	†REACTORS ALSO TO BE USED IN FUTURE BETWEEN BUS SECTIONS
BUCK	GEN. DIRECT TO STEP UP TRANS.		AUTOMATIC O.C.B 13,200 V.	REM. CONT.	OUTDOOR H.T. BUS	101,200	NONE	DIFF. PROT. FOR GEN.	GEN. + TRANS. NEUT. SOLID	
WHIPPANY	GEN. DIRECT TO STEP UP + STEP DOWN TRANS. FOR MAIN + AUX. SERV. RESPECTIVELY		SOLENOID OR O.C.B. 33,000 V.	REM. ELECT.	OUTDOOR	33 KV. PRESENT 66 KV. FUTURE	NONE	BAL. LINE + SINGLE LINE OVER CURRENT, DIRECTIONAL DOUBLE + SINGLE LINE GRD.	THRU 300 OHM R. AT 33 KV. - THRU 150 OHM R. AT 66 KV.	
LAUDERDALE	GEN. TO DISCONN. TO STEP UP TR. TO TIE BUS THRU O.C.B. TO EITHER OF 2 66 KV. BUSES		INDOOR DISCON. + OUTDOOR 73 KV. T.P.S.T. O.C.B. SOLND. OP.	REM. CONT.	OUTDOOR OR 2 SYN. BUS	66 KV.	NONE	DIFF. PROT. FOR GEN.	GEN. NEUTRAL TO GRD. BUS	
HARBOR POINT	FROM GEN. SECT. RING BUS AS SHOWN IN DIAGRAM - GEN. CAN FEED TRANSMISSION LINES SEPARATELY OR IN PARALLEL		C.B. 25,000 V.	REM. ELECT.	VERT. 150. PHASE	13,800	5% ON GEN. & OUTGOING LINES	OVERCURRENT AND DIFF. PROTECTION	GEN. NEUTRAL SOLIDLY GROUNDED THRU S.R NON AUTOMATIC C.B.	
NECHES	—	—	— INFORMATION		NOT	AVAILABLE	—	—	—	
†KIPS BAY	GEN. TO O.C.B. TO BUS		TRUCK TYPE 1200A. 2300V. SOLND. OP.	REM. ELECT.	GROUP	2300 V.	NONE	DIFF. PROT. ON GEN.-OVERLOAD ON FEEDERS	GROUNDING TO WATER PIPE + BLDG. STEEL	†CENTRAL HEATING PLANT ELECTRICITY GENERATED FOR HOUSE SERVICE ONLY
BEACON ST.	GEN. TO OC. B. TO BUS		4800 V. OIL C.B.	REM. ELECT.		275 V D.C.	INFORMATION NOT AVAILABLE			†PRIMARILY CENT. HEATING PLANT - A 3750 K.V.A. GEN. IS INSTALLED
MINNEQUA	GEN. TO O.C.B. TO MAIN BUS TO O.C.B. TO REACTOR TO DISCONN. OR O.C.B. TO AUX. BUS.		OIL C.B. SOLENOID OP.	REM. ELECT.	SINGLE GROUP BUS	6,600 V.	1 REACTOR BETWEEN MAIN + AUX. BUS - 5%	DIFF. PROT. ON GEN. OVER CURRENT ON FEEDERS	NOT GROUNDED	
MASSILLON	GEN. TO REACTOR TO OIL SWS. TO EITHER OR BOTH OF 2 BUSES		O.C.B. MOTOR OP. 11,000 V.	REMOTE ELECTRIC	VERT. GROUP	11,000 V.	IN GEN. LEADS	INDUCTION OVER-CURRENT NO VOLT. REVERSE POWER PHASE FAILURE	INFORMATION UNAVAILABLE	
THREE RIVERS	—	—	— NO ELECTRICITY		GENERATED *		—	—	—	*PAPER MILL PLANT ON ST. LAWRENCE R. - HAS PLENTY OF HYDRO-ELECT. POWER AVAILABLE

this is accomplished merely by the use of a fire wall between the two while in others the switchhouse is an entirely separate building.

The horizontal isolated phase system, because of its higher cost, probably, is not used in any of the newer stations. With this arrangement the three phases of a three-phase system are arranged horizontally across the width of the room with separating walls between.

With the vertical isolated phase system, the respective phases of a three-phase system are each placed on a separate floor, the circuit breakers being operated by vertical rods from the switch mechanism. This method of bus arrangement is more economical of space and lends itself better to the ground area usually available at generating stations. In stations using the vertical system a number of different arrangements are possible. The operating or mechanism room may be placed either at the top of the building on a separate floor or on the ground floor. In a recent installation, that of the new



INSTALLATION OF ARMORCLAD SWITCHES AT WAUKEGAN GENERATING STATION

switchhouse of the Crawford Ave. Station, the necessity for a separate switch mechanism floor has been eliminated by placing the operating mechanism on the small level with one of the phases. This makes use of a new type of operating mechanism which results in a considerable reduction in the total cost of the switchhouse.

Complete isolation involves the use of separate rooms and fire walls for main buses, oil breakers and auxiliary buses of the same phase and in some cases reactors are also isolated. The operating mechanism and disconnect switches are also isolated from the breaker compartments. Each group of equipment is also separated by fire walls in a transverse direction.

Armorclad Switches

An interesting development in the circuit breaker field is the installation of armorclad switchgear at Stanton Station and in the recent additions to the Waukegan Station. This type of switchgear was developed in England by A. Reyrolle and Co., Ltd., but is now being manufactured in America. A view of the installation at Waukegan is illustrated. As can be seen, this is an armorclad equipment with all conductors including bus bars completely enclosed in grounded metal enclosures. The conductors are first adequately insulated. When in place, the space between them and the metal casing is completely filled with solid insulating compound. Series and potential transformers and all disconnecting features are included in the metal clad switchgear. Insulated lead covered cables lead to and from compound filled dividing boxes of the switchgear. Interlocks are provided, making impossible the wrong sequence of operations. The construction is such that it is impossible for a person to make accidental contact or come within arcing distance of a line conductor.

As in the case of the isolated phase question, electrical engineers are not agreed that the armorclad equipment is the final solution to the bus and switching problem. Each arrangement has its particular advantages and both systems no doubt are capable of further improvement.

Bus systems differ in different stations in accordance with the needs of those stations, but a study of existing systems indicates the popularity of the double bus system, particularly when used in conjunction with double breakers. The double bus double breaker system provides maximum flexibility and has all the advantages of the double bus single breaker system with the additional assurance against shut-down of any particular circuit due to circuit breaker trouble.

In many cases a modification of the double bus single breaker system, known as the ring bus system, is used. With this arrangement the two buses are tied together by means of bus tie circuit breakers and disconnecting switches.

Voltages used on bus systems are usually the same as the generator voltages except where all switching is done on the high tension side of the transformers. Reference to tabulation on electrical connections for instance will show that the bus voltages at stations such as Lakeside, Bayside, East River and Morrell St. are the same as the generator voltages.

Bus Protection

Modern generating station design brings about large concentrations of power which under short circuit conditions would result in exceptionally heavy currents in the buses and cable if no protective features were included in the system. Unless sufficient impedance is introduced in the circuit or if protective relays used in conjunction with automatic circuit breakers are not provided to remove the defective circuits from the buses, destructive effects would ensue.

In bus circuits, current limiting impedance can be conveniently provided in the form of current limiting reactors, and most large stations make use of them in one way or another. Their location in the circuit depends primarily upon the amount of power concentrated in the station, the number and grouping of feeder circuits and their respective normal rating. There are three places where reactors can be conveniently located. One is in the individual generator circuit, the second is in the bus bars between generators, and the third is in the outgoing feeder circuits. In certain cases the use of reactors in all three places may be justified but in general this is unnecessary. Modern generators are built with sufficient inherent reactance to

limit short circuit currents to a safe value. Reactors are used mostly between bus sections and in the feeder circuits themselves.

Transformers

Transformer development has kept pace with development in rotating electrical machinery. During the year a number of very large installations have been made, the largest being a 66,667-kv.a., 25-cycle auto transformer at the Charles R. Huntley station of the Buffalo General Electric Co. This is the largest transformer so far constructed in the United States, not only in rating but in physical dimensions. Its construction required 36 t. of steel and 17 t. of copper for windings. It is utilized to step up the voltage from 12,000 to 24,500 v. and its equivalent rating as a transformer is 34,000 v.

Four single phase auto transformers of record size were also built for air cooling. They are rated 30,000 kv.a., 220,000 Y, 125,000 Y, 10,640 v. These units have a larger capacity and exceed in physical dimensions any transformer of this type so far constructed. The conservator which contains 1300 gal. of oil is in itself equivalent in dimensions to the tank required for a 2500-kv.a., 60,000-v. transformer.

Other large transformer units completed during the year were several 31,400 kv.a., 60 cycle, 12,000 to 132,000 Y volts water cooled units and some 25,000 kv.a., 3 phase, 60 cycle 13,000 to 120,000 v. self-cooled units. The latter are equipped with tap changers designed for future tap changing under load.

The question of tap changing under load has grown in importance and there has been a continual growth in the use of transformers provided with tap changing facilities. Transformers of this type are particularly valuable for tying-in two operating systems and with increasing interconnection facilities more of these units are being used. The voltage range for which these equipments are made varies within wide limits, the maximum to date being 120 per cent range in voltage in 18 ratios, and the minimum 10 per cent voltage variation in 9 ratios.

This increasing use of tap changing under load facilities is not reflected in the accompanying tabulation on transformers for several reasons. Tap changing transformers because of their advantages in tying different systems together are more likely to be installed at substation or transformer station centers away from the generating stations than at the generating proper. Furthermore, it is extremely difficult to draw any general conclusions from so comparatively small a list of installations. The tabulations presented in this issue are not intended so much to serve as a basis for general conclusions as they are to indicate the particular sizes and capacities of equipment installed in some of the recent stations.

In the matter of types of transformers in use, it will be noted that in the stations considered, the balance seems to be in favor of the oil insulated self-cooled type, although a number of water-cooled units are installed. This also must not be regarded as a general conclusion since a great many more installations would have to be considered to form an accurate conclusion in this respect.

In the matter of transformer cooling, the development of means to increase the rating of self-cooled transformers by the method of blowing air on the cooling surfaces, which originated a number of years ago, has been applied to a number of large installations during the past year. It has been found that in some cases where transformer efficiency is not of prime importance, the saving effected in the transformer itself is sufficient to affect the cost of the blower and air duct equipment.

An interesting European development along the lines of high voltage testing transformers, reported in the electrical machinery report of the American Institute of Electrical Engineers, are some 750,000-v. units which are constructed on an entirely new principle. It has been the practice to immerse the whole active parts of such a transformer in an oil tank but in this design only the windings are oil immersed. This is accomplished by arranging the inner and the outer insulating

TRANSFORMER DATA

NAME OF STATION	TYPE	PURPOSE	CAP.	WINDING CONN.	POTENT'L CHANGE	LOCATION	COOLING SYSTEM	PROVISION FOR V. VARIATION
LAKESIDE	A-OISC B-OISC	MAIN POWER	A-6-10,000 B-(2-20,000 1-10,000)	Δ-Δ + Y-Y Δ-Y	11,000/22,000 11,000/132,000	OUTDOORS	SELF COOLED	TAP CHANGING UNDER LOAD ON 40,000 KV.A UNIT
BAYSIDE	A-OISC B-OISC C-OISC	MAIN POWER AUXILIARIES LIGHTING	4-7500 3-200 TOTAL-100 MW		11,000/72,000 11,000/22,000 2200/440/110	A-OUTDOORS B- " C-INDOORS	SELF COOLED	
STANTON	A-OIWC B-OISC	MAIN POWER AUXILIARIES	17,500 EA. 2500 EA.	Δ-Y Δ-Δ	14,000/34,000 34,400/66,700 & 66,000/132,000	OUTDOORS	W. & S.C.	NONE
EAST RIVER	A-OISC B-OISC C-AST	60~ FEEDERS STATION POWER FREQ. CHANGERS	3-10000 3-4000 1-18,500	Y-Δ Δ-Δ Δ-Δ	293.95/16000 11000/2300 4W 11000/2300	INDOORS	OIL & AIR BLAST	A) NONE B) C-REACTORS & O.C.B.
MORRELLST.	A-AIWD B-OIWC	MAIN POWER HOUSE SER.	25,000 15.00	Y-Y Y-Δ	13200/24000 24000/480		WATER	A-2½% TAPS B-2½% TAPS
DES MOINES	A-OIWC B-OISC	MAIN POWER	6-6667 3-3333	Δ-Y	138.6/46200 13800/69000	OUTDOORS	W. & S.C.	NONE
BUCK	OIWC	MAIN POWER	3-14,500 PER BANK	Δ-Y	13800/66000	OUTDOORS	WATER	NONE
WHIPPANY	OIWC	MAIN POWER	2-12,500	Δ-Y	4000- 33000/66000		WATER	NONE
LAUDERDALE	OISC	MAIN POWER	10,000 EA	Y-Y	132000/22,000 66,000 (2nd wdg) 11,000 (third wdg)	OUTDOORS	S.C.	NONE
HARBOR POINT	OISC	HOUSE SER.	2-500 2-1500	Δ-Δ	13200/460	INDOORS	S.C.	NONE
NECHES		INFORMATION NOT AVAILABLE						
KIPS BAY	OISC	LIGHTING HOUSE SER. EMERGENCY	67 EA. 1000 EA. 67 EA.		2300/230/115 2300/460 11,000 (two wdg)	INDOORS	S.C.	NONE
BEACON ST.		NO TRANSFORMERS INSTALLED						
MINNEQUA	OISC	GEN. SERVICE	10 UNITS 500 TO 1000 KVA 100-1667 EA.	Δ-Δ	6600/13,200 6600/2,200 6600/220	THROUGHOUT PLANT	S.C.	HAND OPERATED TAP CHANGERS
MASSILLON	OISC	HOUSE SER.	2-500	Δ-Δ	11000/2300	INDOORS	S.C.	
THREE RIVERS		NO ELECTRICITY GENERATED.						

cylinders concentrically in such a way that they form a container for the oil. This allows dispensing with expensive insulating bushings. The following advantages are claimed for this construction:

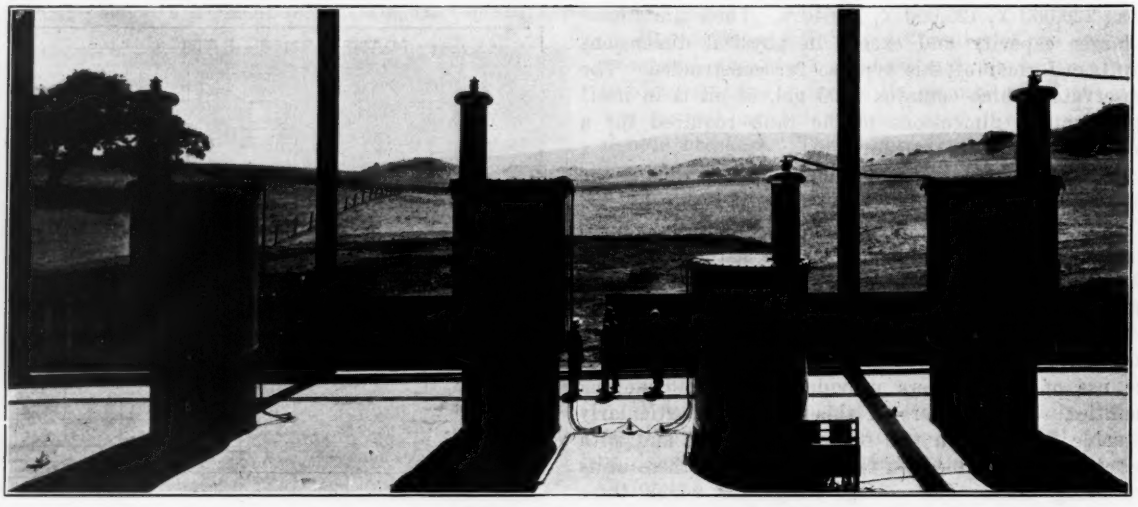
1. Low manufacturing cost, owing to the absence of bushings and tanks and less oil. 2. Small floor space as compared with testing plants using multiple stage cascade connections. 3. Increased reliability, owing to independence from atmospheric influences. 4. Ability to withstand heavy loads owing to the comparatively small leakage voltage.

The important influence of neatly kept buildings, machinery and beautiful grounds, on the minds of the public and employes of public utility companies was emphasized in an address at the meeting of the southwest division, natural gas department, American Gas Association at Houston, Texas, by R. J. Daugherty of The Empire Companies, Bartlesville, Okla. The Empire Companies are in the midst of a campaign to beautify their plants and grounds in Oklahoma and elsewhere. Well maintained properties, the speaker declared, not only favorably impress the public and possess great advertising value, but they stimulate a greater spirit of pride and loyalty on the part of the employes.

Developments in Transmission Practice

USE OF DIRECT CURRENT, LIGHTNING PROTECTION, INTERCONNECTION, CONTROL OF POWER FACTOR, STABILITY, LOW VOLTAGE DISTRIBUTION, AUTOMATIC STATIONS. BY H. R. SUMMERHAYES*

AT THE PRESENT time I can not point to any radical or startling developments which will revolutionize electric power transmission. A good deal of experimental and theoretical work has been done in studying the possibilities of transmission by means of direct current, but the practical outcome of this work is still in the future. While it is true that power is transmitted in several existing installations in France by means of the Thury series direct current system, these plants are relatively small in power and low in voltage, judged by present requirements in this country, and it is significant that no new Thury systems have been installed for about 15 yr. Direct current presents undoubted advantages, as far as the transmission line itself is concerned, by the use of two conductors instead of three, by the transmission of a greater amount of power at a given voltage and by less corona loss for given effective voltage, etc., but is practically ruled out on account of the complication, expense and inefficiency of the converting apparatus at the receiving end.



THE NEW HARRIS J. RYAN HIGH TENSION LABORATORY AT STANFORD UNIVERSITY WILL NO DOUBT CONTRIBUTE MUCH TO OUR KNOWLEDGE OF TRANSMISSION PHENOMENA

Future improvements in the rectifying vacuum tubes may change the situation, but for the present in electrical power transmission the three-phase alternating current system is the only one to be considered and probably will remain so for many years.

While for over 25 yr. the maximum voltages used in power transmission have been steadily increasing, we seem to have reached a point at 220 kv., where the maximum transmission voltage has remained stable for the past 3 or 4 yr. and is likely to remain so for several years more. The reasons for this lie chiefly in economic considerations. In order to obtain any advantage by raising the transmission voltage, it would be apparently desirable to make a good sized step, as from 220 kv., to 330 kv. In doing so, we are confronted immediately with the fact that the kv.a., required to charge the line, or furnish the capacity current at no load, increases with the square of the voltage and that this figure, already large at 220 kv., becomes almost prohibitive at 330 kv., unless the amount of power transmitted is very greatly increased. At the same time, the corona losses go up, requiring the use of larger and more expensive line conductors than heretofore. The insulation requirements become more difficult and due to the increased spacing the cost of line towers is greatly increased. We already have at 220 kv., a pressure capable of transmitting large blocks of power to the maximum distances at present involved and it would appear that a higher voltage will be necessary only if it is required to transmit much larger blocks of power than those heretofore considered, to a greater distance.

LIGHTNING PROTECTION—GROUND WIRES

Protection of high voltage systems by overhead ground wires has received much discussion in the last 20 yr. and the opinions of the engineers have changed back and forth. Many ground wires were put up and trouble was experienced with them, due to a faulty construction. At the same time, there was no way of determining whether the ground wires were doing any good in lightning protection and they were in many cases abandoned. In the last few years the trend of opinion, based on theoretical considerations, laboratory experiments with artificial lightning, and field experience, has gone strongly towards recommending the use of ground wires on nearly all high tension systems.

Among those transmission engineers who have kept in touch with the most recent information and the most

*Engineer, Central Station Department, General Electric Co., Schenectady, N. Y.

advanced practice, I believe it would be the consensus of opinion that all lines at 66 kv., and over, when on steel towers or on wooden structures having the insulator supports grounded, should be protected by ground wires. Many engineers would extend this recommendation down to 33 kv., for important lines.

Tests confirmed by recent field experience indicate that overhead ground wires materially reduce the voltage induced on transmission lines by lightning.

In the last two or three years klydonographs, or surge voltage recorders, have been used on a number of high tension transmission lines and the records of these experiments have shown a few induced lightning voltages over 1,800,000 v. and have also confirmed that voltages higher than the impulse flashover of the insulators can not travel over the line but must be local.

The Dufour cathode ray oscillograph has given us a powerful laboratory tool for recent investigations of the nature of lightning and the action of lightning arresters. With artificial lightning generators it is possible to produce lightning impulses of wave fronts corresponding with those met with on transmission lines. The duration, voltage and shape of these impulses can be measured in millionths of a second with a Dufour oscillograph and the effect of lightning arresters in reducing the voltages can also be measured.

Improvement in cemented and other types of insulators has largely eliminated puncture as the cause of line troubles. Most of the troubles now are due to voltage flashover from lightning with consequent loss of service and sometimes accompanied on high voltage lines by destruction of the insulators and burning off of the line conductor. While the number of flashovers may be reduced by the use of ground wires, it is not expected that ground wires will entirely eliminate flashovers, particularly on those transmission lines which have to be built with the conductors at a considerable height from the ground. At 60 ft. height, for instance, there is a possibility of three or four million volts being induced on the line and even with a 50 per cent reduction by means of ground wires, this would be far beyond the flashover point of the insulators. To reduce the destruction of insulators and burning of conductors by flashovers, it is, therefore, advisable on high power and high tension lines to install arcing rings at the bottom of the string insulators and arcing horns at the tower and also to arrange the relay settings so that the faulty line may be cut off as quickly as possible.

On the lower powered lines it may be possible to permit the arc to hang for a longer time than one second. When the arcs hold on from 4 to 5 sec. on high powered lines they tend to travel away from the tower along the conductor and there are evidences of arcs having traveled at least 150 ft., these cases usually resulting in sufficient burning of the conductor to necessitate replacement even if the conductor was not burned off immediately.

In this country, the tendency for the past 10 yr. has been towards the grounded neutral with the result that switching disturbances do not usually produce voltages over two or three times normal and are not serious factors in apparatus insulation. Operation with dead grounded neutral has also permitted us, where the cheapest apparatus is required, to operate with a somewhat reduced insulation on transformers, switches and other apparatus. On the Pacific Coast, for instance, where lightning is infrequent, much of the 220-kv. apparatus is designed for a test of 2.73 times voltage from line to ground instead of 3.46, which latter corresponds with two times voltage from line to line. By this means considerable saving in the cost of apparatus is made at 220 kv., tapering down to a hardly worthwhile saving at 110 kv. The operation of the solidly grounded systems has proved quite free from voltage troubles due to switching, but we have had to put up with increased currents in short circuits, and particularly in single phase line to ground short circuits.

As the generating capacity connected to our transmission systems has grown enormously, we now have to deal with very large currents and kv.a., not only requiring heavy interrupting capacity in the oil circuit breakers, but considerable increase in the local destruction at the fault; there is also a tendency to make the relay setting shorter, which in turn increases the actual duty on the oil circuit breakers.

Since most faults are initially line-to-ground faults either on the cable systems or on a transmission system, it would appear desirable both to reduce local destruction and to reduce the duty on oil circuit breakers by inserting a moderate amount of resistance or reactance in the neutral. This resistance will vary with the voltage of the system and also with the extent of the system, that is, the charging current and also with the generator capacity connected. Our study indicates that it will be desirable to make a careful compromise between the various conditions involved. If the resistance is too high, the system approaches an isolated neutral and we should again begin to have voltage troubles. Preliminary work indicates that for 33-kv. systems a neutral resistance varying from 30 ohms for a very large system to 75 ohms for smaller generating capacity would be a desirable compromise. For 110 kv., 100 to 200 ohms and for 132 kv., 130 to 250 ohms. Above these voltages the advantages of dead grounding the neutral would probably predominate.

Interconnection—Relays and Circuit Breakers

Interconnection by adding mileage of transmission lines extends the area subject to lightning and other disturbances and increases the number of insulator flashovers and other disturbances which will be felt on a system and tends to cause more interruptions in service unless the relaying is very carefully designed. The tendency is to cause a greater number of brief reductions in voltage and by the fact of having an additional source of power to reduce the number of long interruptions. The problem of the relaying engineer then is to co-ordinate the relay practice of the two systems and combine them so that the number of brief reductions of voltage and brief interruptions of power will be reduced by the interconnection rather than increased. Pending the development of more perfect relay systems with first and second lines of defense which will definitely confine the trouble to a more or less limited area, the general practice has been to adopt what may be called loose linking, in which the attempt is made to keep the two systems tied together, so long as the trouble is local, of limited magnitude, of extremely brief duration and may be taken care of by

local circuit breakers. When a short circuit exceeds a certain magnitude of duration and requires the operation of the circuit breakers on the second line of defense, it has seemed advisable to many engineers to arrange the relaying so that two systems will be split apart.

Results obtained by a perfect pilot wire relay system would seem to be ideal for relay practice in interconnections. Pilot wires have been used quite extensively in England, especially on underground systems. They have not met with much favor in this country, having been installed to a very limited extent on underground systems. On overhead systems in this country they are not used to any extent on account of the expense of the pilot wires and difficulties resulting from capacity, induced voltage, etc. Now that reliable detectors and relays operated by carrier current are available and in use to some extent for supervisory control as well as transmission of intelligence, the logical relay system for most important interconnections, as well as for many parts of the main transmission systems, would appear to be a system involving carrier current and using the transmission conductors themselves for pilot wires, so that the oil circuit breakers on the tie line should open only in cases of trouble on the tie line itself. This may be termed a carrier current pilot wireless system. In accordance with the principle of a second line of defense, however, short circuits of large magnitude and long duration would probably be allowed to open the tie line circuit breakers by additional relays. Such a carrier current pilot relay system is now being installed on an important interconnection in Ohio.

It is also possible to use carrier current over the main transmission conductors to cause the closing and opening of oil circuit breakers, or air break switches, and for other supervisory control operations, when the distance is too great to run ordinary supervisory control wires.

Control of Voltage, Power Factor and Wattless Current

In many interconnections made in the past the power has always flowed in one direction and the necessary voltage gradient would be determined by proper predesign of the transformers and by manual changing of taps with the transformers disconnected. Modern conditions, however, in many cases demand a flow of power in either direction and operating conditions often necessitate that it should be possible to reverse the flow of power at short notice and without shutting down the line. So far as reversing the power alone is concerned, this can be done by adjustments of the governor of the prime movers, but when the voltage gradient is not correct, that is to say, when the sending plant tends to operate at the same voltage, or a lower voltage than the receiving plant, the receiving plant must supply the wattless current required to compensate the lack in voltage drop. Since this must be done by over-exciting the generators and synchronous apparatus at the receiving plant, or by running additional machines, which would not otherwise be used, such a condition inflicts a hardship upon the receiving system. In order that the two systems may share the wattless current in any desired proportion, it is necessary to introduce a method of changing the voltage ratio somewhere in the line interconnecting the two systems. This may be done in one or more of the main banks of transformers at either end of the line.

Stability

With the increase in size of generating stations, and the tendency to increase the power transmitted to load centers and between generating stations, we have, in some cases, reached the limits of stability and a great deal of study and experimental work has been done in the past 5 yr. to determine the maximum power which may be transmitted over a line, both under steady conditions and under transient conditions, such as a momentary ground on one line.

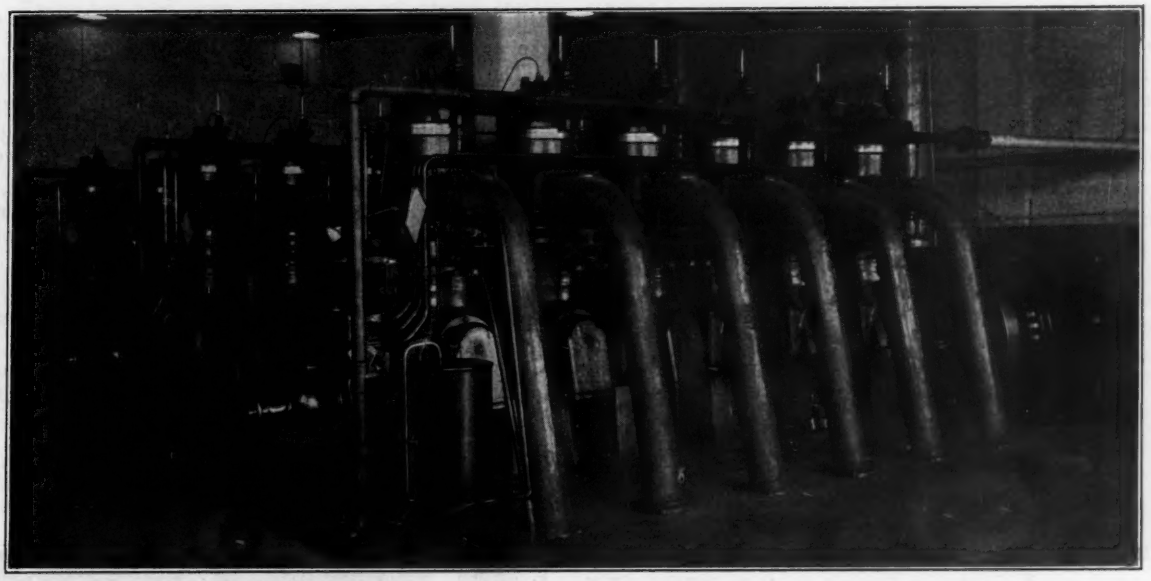
It has also been necessary to determine how this is affected by the characteristics of the generators and other synchronous apparatus, and of the excitation systems and regulators. The limits are now fairly well known, and the studies have shown certain improvements in design of the apparatus, excitation and regulation which will improve the stability and reduce the chance of breaking out of step at extreme loads.

Low Voltage Distribution

During the last two or three years there has been much activity among the central station companies in improving the low voltage distribution system as a whole and in the use of alternating current networks for districts where the load density is sufficient for the network to show economy. This will apply generally to the business districts of cities and good sized towns where the density may be from 10,000 kw., to 50,000 kw., per sq. mi. It is believed that the low voltage alternating current network will supply the system load with reliability equal to that of an Edison direct current system in all respects except the storage battery reserve; further, that when several sources of power are available the service reliability approaches closely that of the Edison system with batteries. The alternating current low voltage network in general supplies power and lighting and may be a three-phase, 4-wire network operating at 120/208 v., or a two-phase, 4-wire, network operating at 115/230 v.

It is also possible to use a network formed by the interconnection of 115/230 single phase 3-wire districts, in which a fourth wire from the other phase supplies 230 v., 3-phase for motors. The different districts have the grounded 3-wire systems on different phases but are interconnected magnetically by transformers or auto transformers to permit the exchange of a certain amount of power between districts.

Transmission engineers are beginning to realize that there are a number of possible applications of vacuum tubes like those used for transmitting or receiving purposes in radio, in which a very small grid current controls a larger plate current. Aside from the carrier current telephone for the load despatchers, which is widely used, some of these applications are as follows: Street light control by carrier current; supervisory station control by carrier current; carrier current pilot wire relay systems, in which the transmission line conductors replace the pilot wires; synchronizing equipments for high tension lines, in which a small condenser built into the bushing of a circuit breaker supplies potential which is amplified by tubes to operate the synchronizer; and high tension voltmeters.



Field for Diesel Engine Power Expands

DEVELOPMENT OF LARGE UNITS AND SMALL, HIGH SPEED, LIGHTER WEIGHT DIESELS HAS EXTENDED THE RANGE OF APPLICATION. BY J. GEORGE OETZEL*

NINETEEN TWENTY-SEVEN has shown a remarkable expansion in the field for Diesel power. This increase in the range of application work is typified by the building of two 12,000-hp., 2-cycle, airless injection Diesels for a generating station in Berlin and by the installation of an 18-kw. Diesel generating set for battery charging by J. C. Zipprich Co. in Chicago. The field between these two extremes of the year's work, in Diesel engine application, is filled with a diversity of uses, many of which mark very definite trends in the use of this type of prime mover.

*Research Division, Fairbanks, Morse & Company, Chicago.

In the general field of power applications represented by the public utility and municipal plants there has been a notable expansion in the number of plants. The year of 1927 will go down in history as the best year, to date, in this particular field of power application.

Aside from the usual factors which are cited as advantageous for the Diesel engines in this field of service, there is one particular characteristic which has unquestionably had a marked influence. This is the fact that there is but a slight difference in efficiency in Diesel engines of large or small capacity and of high or low speed. This characteristic makes the Diesel engine use-

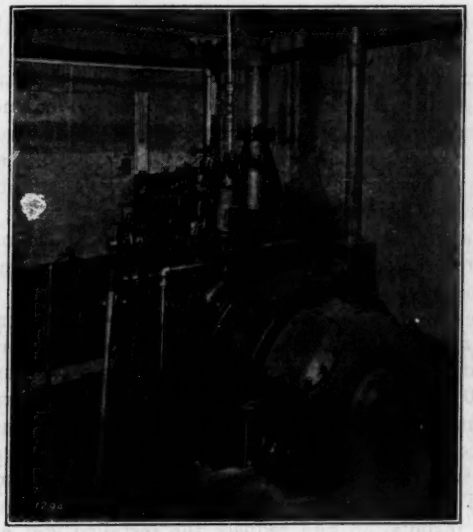


FIG. 1. AN 18-KW. DIESEL GENERATING SET OPERATING AT 800 R. P M., USED FOR BATTERY CHARGING, HAS MADE A SUBSTANTIAL REDUCTION IN COST AS COMPARED WITH PURCHASED POWER

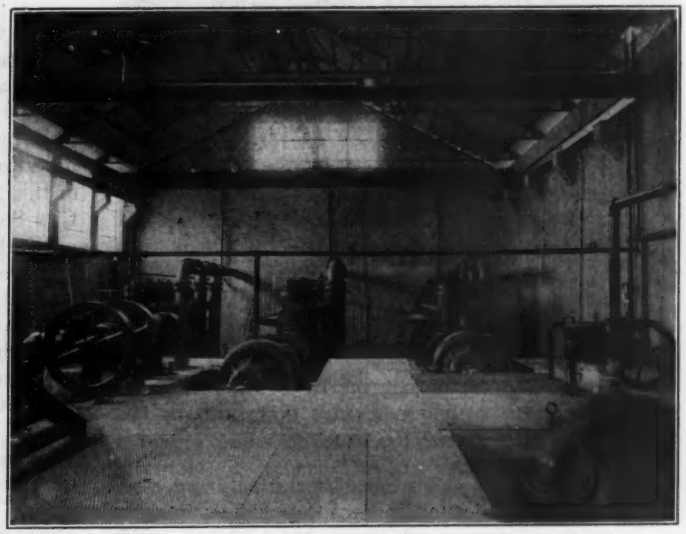


FIG. 2. DIESEL PUMPING PLANTS HAVE MADE RAPID PROGRESS AS ILLUSTRATED BY THIS VIEW OF THREE OF THE SIX 360-HP. DIESEL ENGINES, DIRECT CONNECTED TO 30-IN. CENTRIFUGAL PUMPS WITH A TOTAL CAPACITY OF 180,000 G.P.M.

ful to the public utility companies for extension work, as boosters at the ends of long transmission lines, in providing service in localities where transmission lines are proposed but do not as yet reach and in which the load factor may be poor, and as standby equipment which may be put in service without delay. In the

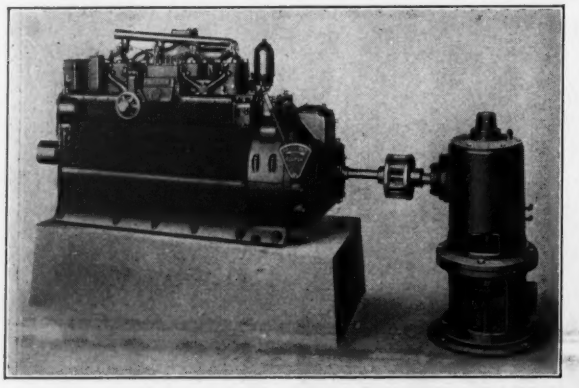


FIG. 3. THE DEVELOPMENT OF HIGHER SPEED, LIGHTER WEIGHT DIESEL ENGINES HAS ADAPTED THIS TYPE OF PRIME MOVER FOR DIRECT CONNECTION TO DRIVEN MACHINERY, AS SHOWN BY THIS VIEW OF A 60-HP., 800-R.P.M. UNIT, DIRECT CONNECTED TO A TURBINE PUMP THROUGH A SPEED INCREASER

case of standby units the Diesel offers the opportunity of clutch coupling its generator for use as a synchronous condenser for power factor correction when not required for power generation purposes.

Diesel engines have also made remarkable progress during the past year in the general industrial power field. There have been many applications in woodwork-

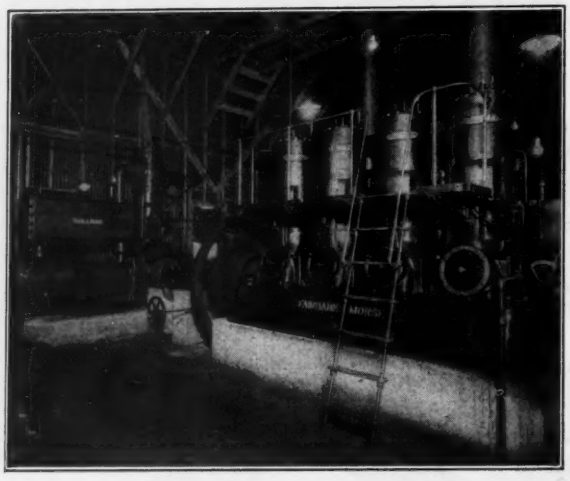


FIG. 4. THIS 240-HP. DIESEL, DIRECT CONNECTED TO AN ANGLE COMPOUND COMPRESSOR, WAS INSTALLED IN CONNECTION WITH A TUNNEL JOB

ing plants, machine shops, small manufacturing establishments, cotton seed oil mills, brick plants, quarries, construction projects, coal mines, hotels, textile mills, packing plants and dairies where the Diesel engine has never before been considered as a logical prime mover. Improved efficiency, reliability, better quality and lower cost of Diesel engines have undoubtedly had much to do with making it possible for industrial organizations to take advantage of the economy of Diesel power.

The development of Diesel engines in smaller sizes and in higher speed and lighter weight units is having a pronounced effect in the solution of the small industrial plant's power problem. The cost per horsepower of these higher speed, lighter weight, Diesel engines is approximately the same as for the large, slower speed engines, however, the installed cost is considerably lower. This is due to the fact that the labor cost of installation is less, a smaller foundation is required, the building cost is lower and the cost of the higher speed generator is considerably less.

Another field for Diesel power which has made considerable progress during the year is in connection with pumping installations. The direct connection of Diesel engines to either centrifugal or screw pumps makes a very compact, highly efficient unit with which it has been found possible to pump water at remarkably low

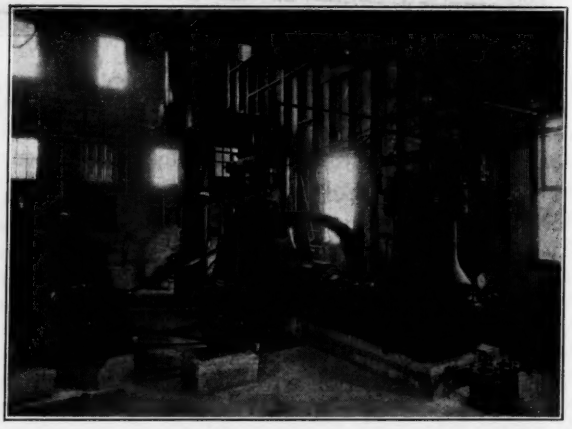


FIG. 5. A 120-HP. DIESEL, DIRECT CONNECTED TO A 10 BY 10-IN. COMPRESSOR, IN THE PLANT OF THE VIRGINIA ICE & FUEL CO. AT DOUGLAS STATION, VIRGINIA

costs. One installation recently completed in the southwest has six 360-hp. Diesel engines direct connected to 30-in. centrifugal pumps with a combined capacity of 180,000 g.p.m. Another application of Diesel engines to a pumping plant is the direct connection of these units to closed impeller sewage pumps. An installation of this type has recently been completed by the Atlantic City Sewage Company at Atlantic City, New Jersey.

Still another recent pumping development is the use of higher speed, lighter weight Diesel engines for direct connection to deep well turbine pumps. The engine in this case operates at 800 r.p.m. and drives a pump through a speed increaser with gear ratios properly proportioned for the speed of the pump, which may range from 900 to 1800 r.p.m. In the past where the Diesel engine has been used to drive a turbine pump it has been necessary to drive the pump by a belt making a quarter turn to a pulley mounted on the turbine pump shaft. The new direct connection makes a much more compact installation and reduces the installed cost approximately 25 per cent. In the solution of any pumping problem requiring a lift beyond the range of the centrifugal pump the Diesel-driven turbine pump offers extremely interesting possibilities.

There has also been a wider use of Diesel engine compressor units particularly in connection with construction operations, mining and for air lift pumping work. In remote sections where fuel costs are high, these units have made some amazing cost reductions. Even in the metropolitan areas, however, these units are being used in increasing numbers. Arthur McMullen, a contractor for one section of the New York subway, is using two 240-hp. engines driving angle compound compressors in connection with the subway construction work. Another installation is at the new Proviso Yard of the Northwestern Railway Company in Chicago. The new Proviso Yard is the largest classification yard in the world. Here the compressed air requirements are being supplied by a 180-hp. Diesel direct connected to a compressor.

There has also been a trend in the ice and refrigeration field towards the use of direct connected Diesel units. For a time this development was retarded due to the fact that ammonia compressor speeds of 250 or 300 r.p.m. were considered too high to be practical. Continued studies of the problem on the part of designing

FIG. 6. THIS 6-YD. WALKING DRAG LINE EXCAVATOR, EQUIPPED WITH A 240-HP. DIESEL, IS THE LARGEST MACHINE OF ITS TYPE EVER BUILT AND IS OPERATED IN CONNECTION WITH LARGE IRRIGATION PROJECTS IN THE SOUTHWEST

engineers of ammonia compressor manufacturers resulted in the development of a highly efficient high speed compressor which could be direct connected to Diesel engines. Many of such units have been installed during the year and are giving an excellent account of themselves in reducing the cost of producing ice.

In the field of excavating machinery there has been very marked progress during the year. The range of use has been extended to both larger and smaller sizes of drag lines, shovels and various other types of both marine and land excavating equipment. The automotive type of gasoline engine has developed an extensive field of application in such machinery. In order to make the Diesel engine competitive with it, it was necessary to decrease the ratio of weight to horsepower and to make the engines much more compact. Several developments along this line were announced during the year, the general trend of these being in higher speeds up to 900 r.p.m., and in the use of block cylinders very similar to automotive type of construction. As a result of this development it is now possible to equip excavating machinery as small as a one-yard shovel or drag line on a basis which is competitive with gasoline power and with a considerable saving in operating cost to the purchaser.

The Diesel engine continued to progress in the railway field and Diesel engines for locomotive use are now under construction in powers up to 1200 hp. Several railroads are operating Diesel locomotives with engines of 300 to 400 hp. and with rotative speeds up to about 600 r.p.m. The most important field for the railways will undoubtedly be the use of Diesel locomotives in yard service particularly in cities. Reduction in cost of operation and the elimination of the smoke nuisance at a much lower initial cost than electrification are two strong arguments for the use of Diesel locomotives.

Official Classification of Fire Brick Shapes Now Available

HISTORY of the refractories industry has not been unlike that of many others in so far as "trade secrets" are concerned. The individual manufacturer's methods were strictly "private property," to be cherished as a birthright, and the prerogative prevailed throughout the industry.

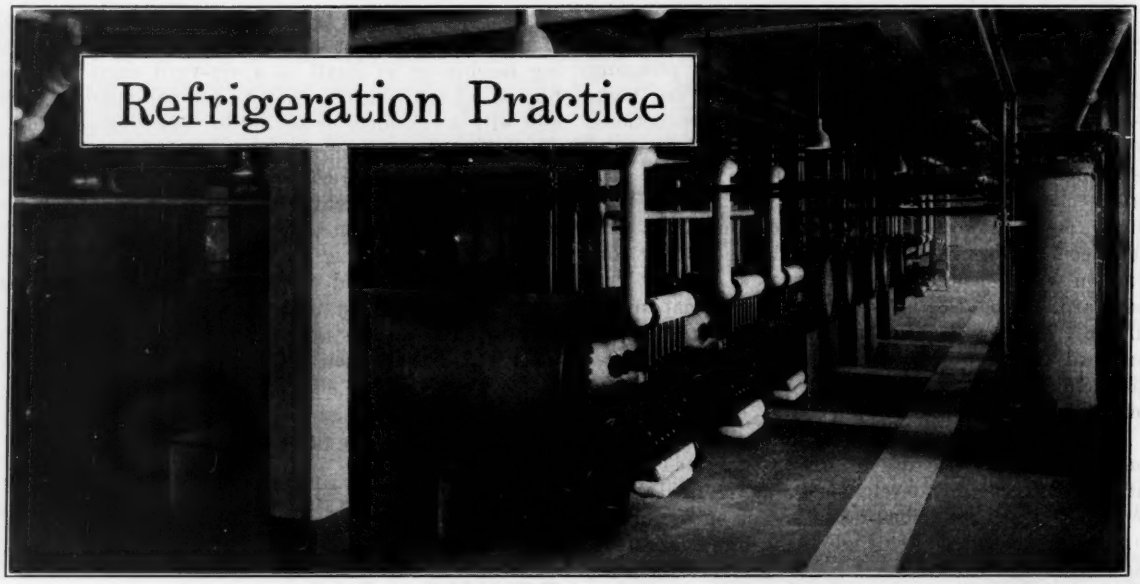
Renaissance in the refractories industry takes definite shape in the publication of a report by the Classification Committee of the American Refractories Institute. The report is in the form of a set of rules and formulas adopted by the Institute and is entitled "Classification of Fire Clay Shapes Other than Straight Tile." This code places upon a commonly-accepted basis the methods of determining costs of all special fire brick shapes.

Rule I deals with the Method of Squaring Irregular Shapes. This is the basic rule for the entire system of classification, and it is logically followed by seven other rules of general character. These cover Volume Reduction, Applying Composite Base, Mould Expense, Quantity Differentials, Over-shipments, Determining 9-in. Equivalent and Disposition of Decimals in Piece Prices.

With the eight general rules established, every shape —from the simple arch, key or wedge to the intricate notched and hollow forms—is classified in accordance with twelve distinct groups.

"Classification of Fire Clay Shapes other than Rectangular Tile" is now available for distribution to those persons actually identified with the purchasing of fire brick. Copies may be obtained by writing to the American Refractories Institute, Oliver Building, Pittsburgh, Pa., or to any fire brick manufacturer.

DEPARTMENT OF COMMERCE, Washington, D. C., in its report on mechanical stokers for October, 1927, states that, as reported by 12 establishments, a total of 95 stokers were sold during October, installed under boilers of 27,222 hp. capacity. This capacity is practically the same as that for September, but the total number is 9 less. This decrease was mostly in stokers installed under fire-tube boilers. The total capacity installed under water-tube boilers increased slightly.



Refrigeration Practice

Recent Developments in Refrigeration

THE CLOSED TYPE AMMONIA COMPRESSOR, AND THE SHELL TYPE CONDENSER ARE SOME OF THE MORE IMPORTANT REFRIGERATING DEVELOPMENTS. BY TERRY MITCHELL

IN CONSIDERING recent developments in the field of mechanical refrigeration it is convenient to discuss the subject under three separate headings, i. e., compressors, condensing equipment and ice-making systems.

Perhaps the outstanding improvement in enclosed type ammonia compressors in recent years is the addition of forced feed oiling systems to machines of larger sizes. Oiling systems on modern compressors furnish oil under pressure to the main bearings, crank and wrist pins and provide a plentiful supply of oil, but not under pressure to the stuffing box. Such systems are adapted to varying ammonia pressures in the crankcase and create no end thrust on the shaft.

In order to prevent the machine from pumping oil, whether using force feed lubrication or not, modern enclosed compressors are being fitted with special oil scraper rings on the lower part of the piston, these rings being so shaped as to stop excess oil from passing upward.

Drain holes are drilled in the skirt of the piston to carry off the oil collected by the scraper rings.

Prominent oil companies are recommending the use of a heavier grade of lubricant for enclosed machines than formerly employed. Nothing but the purest mineral base oil, highly refined and possessing low carbon forming properties, is to be considered. Oil with a paraffin base is preferred.

With better oil and improved lubrication systems have come higher operating speeds for compressors. This has involved direct-connecting the machines to prime motors such as synchronous motors and oil engines, as well as to the steam engines of old. The desire to get a larger refrigerating capacity from a unit of the enclosed type has led to what may be termed the duplex-coupled arrangement, in which a synchronous motor is mounted between two compressors, placed in line with one another. This plan requires only a single motor, with but one set of starting equipment, and it saves valuable space in the engine room. Either of the machines can be disconnected when desired.

Horizontal ammonia compressors are also being built for higher speeds, the cylinders being designed with radial valves and low clearance volume. A successful machine of this type must have light reciprocating parts, which partly accounts for the preference shown for long-stroke cylinders by various builders.

The enclosed type compressor has also invaded the carbon dioxide field and is proving popular for the same reason that it became the favorite design for ammonia work. With carbon dioxide the main problems are to obtain sufficient bearing surface for the piston pin and to get efficient lubrication to the wearing surfaces, the enclosed pattern makes it necessary to adopt special means for overcoming these obstacles. This type also makes necessary the use of a thrust bearing to hold the shaft in place endwise. These machines are therefore built with an enlarged end opposite the stuffing box through which the entire crankshaft is inserted. This enlarged section of the crankcase contains a force feed oil pump and thrust bearing.

CONDENSING EQUIPMENT

The shell type of ammonia condenser is being used widely today. Some of its advantages are compactness, simple water distribution, easy cleaning, short ammonia headers, freedom from bottling up, high efficiency, lighter weight, lower cost, reserve space for storing liquid, simple purging, and the fact that it can be installed in the machine room when desired. The water in the tubes has a high velocity, as it swirls downward, and the liquid keeps the other side of the tube wet: both these factors increase the transfer of heat and make for good efficiency in this type condenser. It was for-

merly considered necessary to build shell condensers in 18-ft. lengths, but experiment and experience have shown that a condenser 14 ft. high is equally as effective.

Shell and tube condensers have invaded the small plant field, and we find them on combined refrigerating machines. For such service the tubes are necessarily short, and the water is passed back and forth through the tubes in succession instead of flowing straight in and out. One or two enterprising manufacturers are using radiafin pipes in the condensers, instead of plain tubes; the fins are wound in a spiral on the outside of the pipe, and they increase the heat-absorbing surface very materially.

Non-condensable gas separators, several makes of which are now on the market, have done a great deal to increase condenser efficiency and lower the head pressure. The savings to be made through these purgers is often remarkable. In the case of an average 25-t. ice plant, an extra 10 lb. discharge pressure means 55 kw-hr. additional power consumed per day. A little figuring will show that, at the usual power rates, a purger which lowers the head pressure 10 lb. in such a plant will pay for itself in less than a year. The purger can be connected either to the condenser or the receiver.

Two types of discharge gas precoolers have lately come into favor. Both are really shell condensers of reduced size, the principal difference being in the amount of water passing through the tubes. The larger type is connected to the condensing water pump, and accommodates all or most of the cooling water, which is forced through it in a single pass, after leaving the regular condensers. For plants somewhat deficient in condensing surface this precooler gives desirable results.

The smaller type has the tubes arranged for a multi-pass travel of the water, which is fed in a limited quantity only, so that it is warmed enough for use about the plant in the thawing needle, dip tank, or wash basins. Both of these pieces of auxiliary condensing equipment aid in separating the oil and removing superheat from the discharge gas. They should be located so as to drain any liquid ammonia collecting in them into the regular condensers and receiver.

Liquid precooling has also become popular for large plants. By using a special direct expansion drum, fitted with pipe coils carrying the liquid, the ammonia can be precooled before it reaches the expansion valve, and a small compressor can be worked at high suction pressure, on the precooler alone. Where a great quantity of liquid is being handled, the condensers cannot be expected to cool it to the most economical point, and marked savings can be made by running a separate machine at high suction pressure on a liquid precooler. Another way is to pass the liquid ammonia through a spiral coil placed in accumulator or trap, the suction gas to the machine being depended upon to precool the liquid.

Ice-Making Systems

For all except the most difficult or unusual conditions, the raw water system of making ice is the only one to be considered today. Low pressure air systems as a means for agitating the raw water have also come into general use. But the low pressure system has shown such economies in horsepower required for pumping the air, and in the equipment needed for the system, not to mention the saving in upkeep, that it may now be said to have swept everything before it. The air pressure used in the latest designs is less than two pounds, which is supplied by a simple blower, as opposed to the 15 or more pounds formerly thought necessary, with the air compressors, air receivers, etc., that had to be used to keep up the higher pressure. Furthermore, the best methods of low pressure air agitation call for no dehydration or cooling of the air: this does away with the expensive and troublesome air conditioners, brine sprays, or other special equipment, and means a real saving in refrigeration. The air supply, in what is doubtless the most perfected raw water system, is drawn from the under the tank tops, where a cool, even temperature is maintained at all times.

In the low pressure system the air is admitted to the water through a brass tube suspended in the center of the can. It has been found that this tube should be free to swing across the can the short way, but it must be restrained from swinging the long way, or the tube will be caught in a slanting position as the ice freezes in at the bottom of the core: the result would be a large white core. By keeping the drop tube right in the center of the can and providing it with suitable perfora-

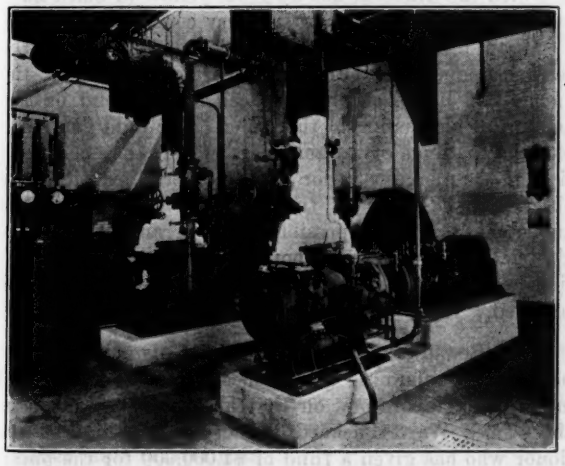


FIG. 1. MODERN TYPE HORIZONTAL AMMONIA COMPRESSORS

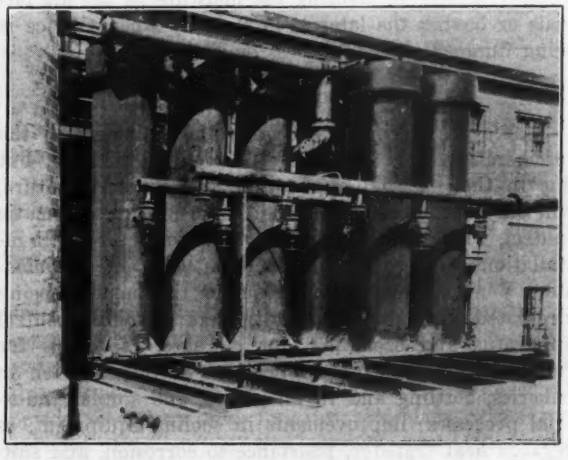


FIG. 2. A BANK OF SEVEN SHELL TYPE CONDENSERS

tions along its length, the core can be made as small as to be practically negligible. This plan also has the advantage that, in case the air supply fails temporarily, due to the power going "off", the perforations in the tube are surrounded by the unfrozen water in the core of the ice, and there is nothing to close them before the air comes on again. Thus an interruption of many minutes may occur without noticeably affecting the quality of ice.

Another important development in the ice-making field has been the handling of the cans in multiple, known as group lift. Group lift equipment, if well built, allows the tank man to remove, dump, refill and replace half a row of cans in the average tank, in ten minutes; this means that he has about half an hour of free time that would have been taken up in harvesting the ice only two cakes at a lift. For large tanks, whole row lift is often preferred. The more carefully designed group lifts are arranged to permit a free flow of brine around the tops of the cans, in order to get the quick

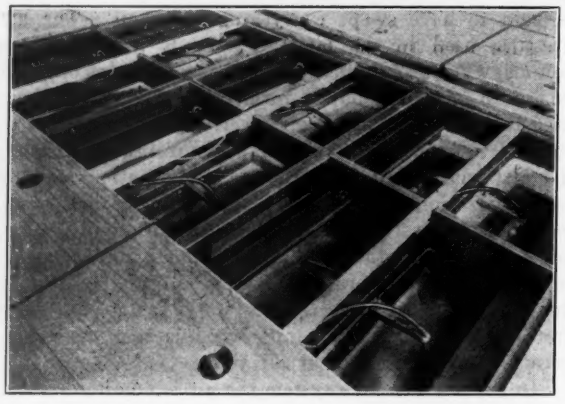


FIG. 3. TANK FRAMEWORK FOR LOW PRESSURE AIR AND PENDULUM TUBES

freezing and oversized blocks now demanded by owners and ice distributors. The lifting frame or grid should be heavy enough to give full submergence of the cans; it should also take the place of the wooden framework, as well as being adapted to the use of low pressure air without danger of freezing the moisture in the air laterals or having the laterals in the way when the ice is being dumped.

Miscellaneous

There are a number of other developments in the refrigerating field which are worthy of mention, but due to their special application and involved nature, will only be touched on here. These include automatic control, which is being used on a majority of small installations; recording instruments, such as thermometers, Venturi meters (for measuring the ammonia being circulated) and recording wattmeters; humidity control apparatus and ozonators, for storages, especially for fruit and other foods; applications of refrigeration in bakeries, bottling and rayon plants, and similar industrial processes; improvements in cooling equipment, as regards heat transfer, resistance to corrosion, and suitability for special services; and so on.

Trace of Mercury Easily Detected

AS SMALL a proportion as one part of mercury in 20,000,000 parts of the atmosphere can be measured accurately by a device which has been developed in the research laboratory of the General Electric Company; one in 8,000,000 parts can be determined quickly.

Mercury poison is accumulative; it seems to make little if any difference whether the amount of vapor is inhaled as relatively large amounts in a short period of time, or as slight amounts over a period of months. Because of the increased industrial use of mercury in heating operations, in various chemical processes and in the newly developed mercury turbine, it has become important to have a method whereby leaks in apparatus and traces of mercury vapor in the atmosphere can be detected quickly.

Previous methods of determining the amount of mercury vapor in the atmosphere were tedious processes that required considerable time and the services of an expert chemist, and even then the results were usually far from accurate, especially when considering tiny amounts of the substance. The new method gives quick results, does not require chemical training to carry out, and is accurate.

The principle on which the new method is based is a reaction between a solid substance, selenium sulphide, and the mercury vapor, with the reaction product a colored substance easily observable with the eye. The yellow selenium sulphide is applied as a coating on paper. The paper is blackened on exposure to air containing mercury vapor, the degree of blackening depending on the concentration of the mercury, the time of exposure, and various other factors which can be definitely controlled. There seems to be practically no lower limit to concentration that can be detected by this method.

For continuous and automatic registration of the mercury vapor, there has been devised a system in which a continuous strip of the coated paper is drawn slowly over an opening through which the air flows, a small clock motor moving the strip of paper at a uniform rate. A short time after the exposure, the colored strip of paper can be compared with a standard scale, in which the different shades from yellow to black have been calibrated in terms of mercury concentration.

If an incandescent lamp is placed in front of the strip of paper and a photoelectric cell behind it, the amount of light reaching the cell will depend on the amount of blackening of the paper. The light can regulate the readings of an ammeter, so that the concentration of the mercury vapor can be determined either by observing the color of the paper or by reading the ammeter. It is also possible so to arrange the photoelectric cell circuit that, should the mercury concentration become dangerously high, a warning gong will be sounded. The apparatus is then an automatic chemist.

THE BOARD OF TRUSTEES, Lehigh University, Bethlehem, Pa., is planning a new mechanical and electrical engineering laboratory on the campus to be known as the James Ward Packard memorial, in honor of the donor who has given a fund of $1,000,000 for the building and equipment.

LETTERS DIRECT FROM THE PLANT

Superheating Exhaust Steam Rarely Pays

SUPERHEATING exhaust steam is frequently advocated. It sounds good. However, there is a "nigger in the woodpile," which it might be well to discuss. I shall endeavor, therefore, to point out the impracticability and uselessness of this method.

Suppose "A" is a steam coil located in a room which is to be heated to a temperature of 250 deg. F. Now, the temperature of exhaust steam at atmospheric pressure is 212 deg. F., so an engineer approaches the owner and says: "Why not heat your exhaust steam from 212 deg. to 260 deg.—a difference of 48 deg.—and you can easily obtain the 250 deg. temperature desired in the chamber? This looks alluring to the owner who knows nothing about the physical properties of steam, and he tells the engineer without further thought to go ahead and have the superheater put in.

The superheater is installed; the exhaust steam is passed through the superheater and superheated to the temperatures of 260 deg. The arrangement works very nicely for a while until a certain temperature is reached in the chamber, but after that it is discovered that something is wrong. For some reason or other, the superheater doesn't work.

What is the matter? The explanation is this: Exhaust steam at atmospheric pressure will not condense unless the temperature surrounding it is less than 212 deg. F. Hence, the steam coils simply fill up with steam, and the steam remains there as long as the temperature is higher than the temperature corrsponding to atmospheric pressure, which is 212 deg. Therefore, it is virtually impossible to attain a higher temperature than this.

Ordinarily, without superheating, to attain a temperature of 260 deg. in the steam coils a gage pressure of 21 lb. per sq. in. is necessary. Then as long as the temperature in the surrounding chamber is less than 260 deg., the steam within the coils will condense, and it can be trapped out easily. Hence, with live steam, no difficulty is experienced in maintaining a temperature of 260 deg. in the chamber as long as the heating surface is efficient.

Where the superheated steam can be passed through the steam coils, thus keeping it in motion, and this exhaust from the coils used for heating at a lower temperature, superheaters may be profitably employed, but this should be looked into carefully, since it can be proved that in many instances the use of a superheater does not produce any gain in the steam economy, but rather adds in first cost.

Instead of superheating the exhaust steam under these conditions, it is frequently more economical simply to heat the surface of the chamber by means of high pressure steam or other means.

Newark, N. J. W. F. SCHAPHORST.

An Unusual Voltage Complaint

WHAT SEEMED to me a very interesting case of unbalanced voltage was reported to a large electric company a short time ago.

The complainant's attention was first drawn to the

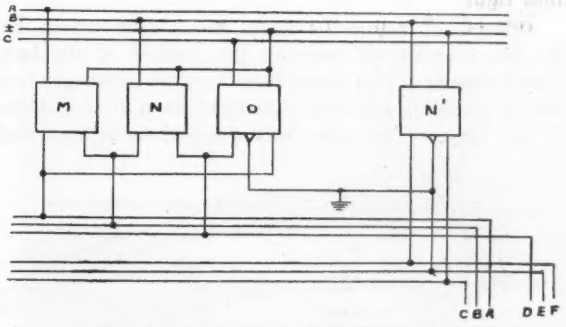


FIG. 1. DIAGRAM SHOWING TRANSFORMER CONNECTIONS

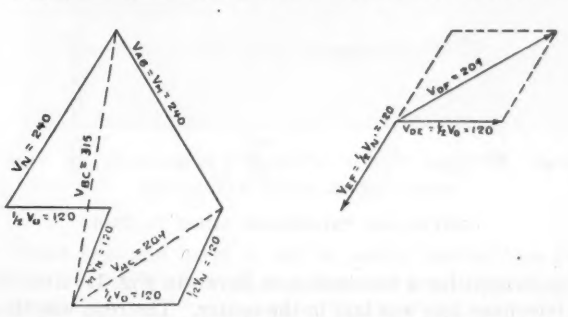


FIG. 2. VECTOR DIAGRAM AND VOLTAGES RESULTING FROM THE CONNECTION SHOWN IN FIG. 1

case by the persistent blowing of fuses on one phase of the power circuit.

A troubleman sent out to investigate the situation found that the customer was supplied with power from a power bank and with light from a separate lighting transformer.

The mid-point of the secondary of the C-phase power transformer and the mid-point of the lighting transformer secondary were grounded in accordance with standard practice. Everything in connection with the transformer installation was satisfactory; however, the power secondary and lighting secondary wires were grouped together in one conduit and where they emerged at the consumers' main power and light switches one power wire had been interchanged with

one lighting wire as illustrated in Fig. 1. Figure 2 shows the vector diagram and the voltages resulting from the aforementioned condition.

Since transformer N and transformer N^1 are on the same phase their voltage vectors are parallel.

^{V}AB, ^{V}BC, and ^{V}AC represent the voltages supplied to the motor terminals by this incorrent connection while V_{EF}, V_{DE}, and V_{DF}, are the voltages on the lighting circuit.

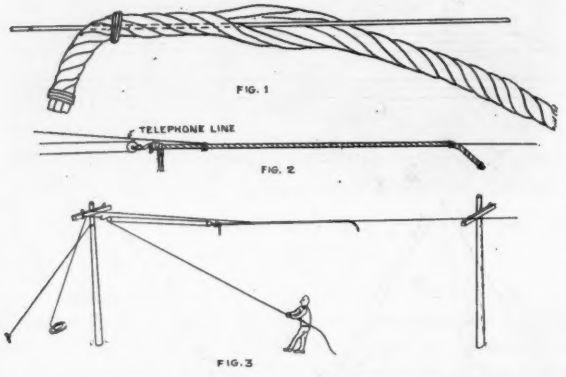
It will be seen that the 120-v. lighting circuits are unaffected. Only across the two outside legs of the lighting circuit was the voltage below normal, being 209 instead of the expected 240. This fact provided the first clue to the trouble.

New York, N. Y. VERNON W. PALEN.

Installing Telephone Lines in India

SEVERAL YEARS ago, while on a visit to Dellu, India, I saw telephone lines being run in what was to me a most novel way; that is, their method of stretching the lines tight.

Instead of using the usual metal clip, which has the disadvantage of marring the surface of the hard drawn copper which sometimes leads to breakage, they used a piece of one-inch diameter hemp rope. About 12 ft. long. The rope was grasped near one end,



INSTALLING TELEPHONE LINES IN INDIA

untwisted for a few inches, as shown in Fig. 1. And the telephone line was laid in the center. The rope was then allowed to retwist itself, and embrace the telephone line at its core.

A siezing was then put on at A, and the free end of the rope was passed over the telephone line in the right direction and at the same time it was untwisted so as to cause the telephone line to form its core. This was continued until nearly the end of the rope was reached. When another siezing similar to A was put on. All this was done in less time than it has taken me to describe it.

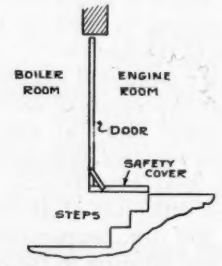
When finished it had the appearance of Fig. 2, and Fig. 3 shows how the line was hauled tight. Only one line is shown here for clearness. Actually two lines were hauled tight at the same time, using two sets of falls, and two clamping ropes.

The harder the pull, the tighter the grip and slipping is impossible. I have clamped a hemp rope ¾ in. diam. onto a piece of $\frac{1}{16}$-in. baling wire in this manner. And hauling with a light set of blocks, have broken the wire, with no slipping and no kinking of the wire.

Long Beach, Calif. E. J. JORDAN.

Drop Cover Over Steps Avoids Accidents

HOW AN ENGINEER eliminated the possibility of a broken leg or other injury in his engine room is shown in the sketch herewith. The door shown used to swing into the boiler room but there was always a "hole" in the engine room over the steps into which a passer-by might fall. By changing the door to swing into the engine room and attaching the "shelf" to the door as shown in the sketch, the opening is now always covered



SAFETY COVER ON DOOR ACTS AS GUARD

when the door is closed. Of course the door can be swung through only 90 deg. with the shelf on it, but that is no great inconvenience and is far preferable to a maimed body.

Newark, N. J. N. G. NEAR.

Heating Feedwater to More Than 212 Degrees

POSSIBILITIES of heating feedwater above the customary temperature of 212 deg. in the average industrial plant are worth while investigating even though few plants are equipped to do so. In the noncondensing plant one back pressure only is considered sufficient for the feed heating system, but if maximum economy and utilization of exhaust steam is realized, an extra heater can profitably be added to the system. In one plant the writer found the exhaust of a noncondensing engine, along with the exhaust of steam drive auxiliaries, going through a closed heater and a back pressure valve at atmospheric pressure giving a feed temperature of 208 deg. The feedwater quantity was around 15,000 lb. per hr. and I wrote a heater manufacturer for the cost of a heater to operate at 25 lb. back pressure to utilize the exhaust of certain auxiliaries that could exhaust against this pressure. The cost of heater, piping and valves as connected was $478 and the increase in feed temperature to 263 deg. reduced the fuel costs by $110 per month. Some readers may question why the theoretical saving of 5 per cent due to raising feed temperature 55 deg. was not obtained as with a total fuel cost of $4000 per month the per cent saving was 2.75 per cent. The steam consumption of auxiliaries was increased slightly by exhausting against 25 lb. back pressure and this increase in steam used had to be deducted from the theoretical gain in feed heating. By

supplying the low pressure heater with main engine exhaust alone a greater amount of engine exhaust was condensed in this heater. Equal or greater fuel savings could, of course, have been made by using an economizer, but the greater amount of heating surface required due to low heat transfer rates would cost so much that the net saving would have been less.

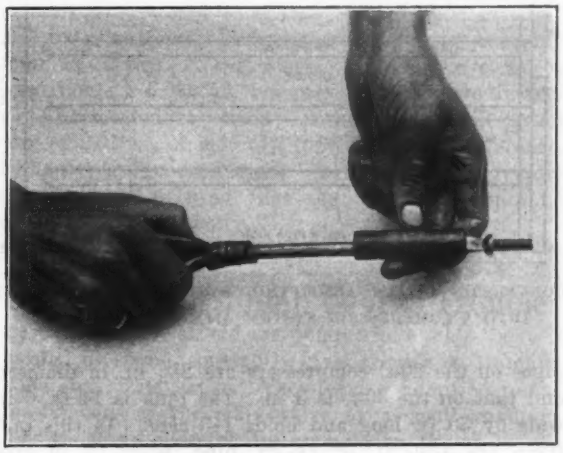
Connecting a heater to the receiver of compound engines will heat the feedwater considerably higher than if only atmospheric pressure is carried on the steam side. This is especially true of noncondensing compounds as the receiver pressure is high, usually 30 to 40 lb. gage. At 40 lb. the water can be heated to 280 deg. Thus the amount of steam exhausted from the low pressure cylinder may be reduced by approximately 50 per cent of the amount bled. Where fairly high process pressures are used as in a paper mill, a heater can be added to operate at the process pressure which will often eliminate the evil of excess exhaust from prime movers. In one mill where three engines exhausted into the dryers at 20 lb. back pressure, there was too much exhaust and the back pressure valve was never closed. A 40-hp. motor was installed on one machine to eliminate the excess exhaust, but in one year of operation used 245,000 kw-hr. which were generated by a condensing prime mover at a steam rate of 20 lb. per kw-hr. Still there was a waste of 4,900,000 lb. of steam per year, which at 50 cents per thousand lb. amounted to $2450. The feed was heated to 210 deg. in an open heater and after the engineer had looked at the problem from every angle, he decided to install a heater of the closed type to take steam from the paper machine header at 20 lb. pressure, and the engine was again put in operation. Very little steam went through the back pressure valve from then on and the feed temperature varied from 250 to 255 deg., representing a gain of over 40 deg.

If there is any great amount of return from high pressure processes, it should be returned direct to the boiler at the same temperature as the process instead of the usual practice of letting them go into an open heater to drop to 212 deg. In a large plant 40 per cent of the boiler feed was condensate from a process using 50 lb. steam pressure and ordinary traps discharged into the heater, thus allowing the condensate at 307 deg. to be cooled to 212 deg. and a considerable amount flashed into steam and was lost through the vent. Even though all of the heat released between 307 and 212 deg. was used to heat the makeup in the heater a loss was still involved. A turbine was bled at 2 lb. to supply the heater, 30,000 lb. per hour being heater. As the heat released by 12,000 lb. of condensate in the heater amounted to 1,140,000 B.t.u. per hour, it follows that if traps fed to boilers about 1200 lb. more steam could be bled from the turbine to heat the makeup, thus utilizing the extraction principle to a greater extent. Then with 40 per cent of the feed going to the boilers at 307 deg. and the remaining 60 per cent at 212 deg. the average temperature would be 250 deg. Where large quantities of steam are used in a process in which the steam mingles directly with the material or liquid being heated so that the condensate is lost, considerable hot, pure feedwater can be secured by placing a separator and trap on the line supplying the process at the point of use, and draining all moisture from the steam. If reducing valves or throttling devices are used on the process, the steam should enter the separator before pressure is reduced as the condensate will be hotter and there is more condensate on the high pressure side as some condensate will be lost by flashing when the pressure is reduced. For every pound of condensate saved in this way, one pound less makeup is required and the condensate does not contain the scale forming properties of the makeup.

Springfield, Mass. A. F. SHEEHAN.

Protection Permits Manipulation of Hot Screw Driver

SMALL MACHINE screws are often accidentally lost, and seem to jump away from us particularly when removing them in close and cramped quarters, from hot parts of machinery, or parts under tension which is relieved suddenly when the screw comes out. The composition body of an old fuse cartridge is an excellent thing to cover the screw with while turning it out.



HOT OR INACCESSIBLE SCREWS EASILY REMOVED WHEN PROTECTIVE PIECE IS EMPLOYED

When free and loose, it can be safely held in this improvised container until you dump or toss it into a safe place.

Particularly handy is this method when removing screws from places where heat makes it impossible to hold or catch the screw in the fingers or hand. The composition is always light and cool although one end of it may be pressed to a hot surface for quite a while.

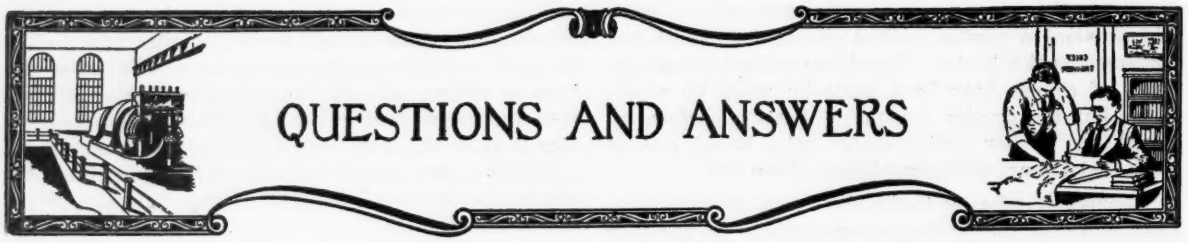
Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

Rubber Shod Ladder Feet

THE NON-SLIP rubber feet for a ladder described by H. L. Wheeler in the Sept. 1 issue are probably excellent as long as the floor is free from water or grease. Wearers of rubber heels know how treacherous they can be when a wet or greasy floor is trod upon.

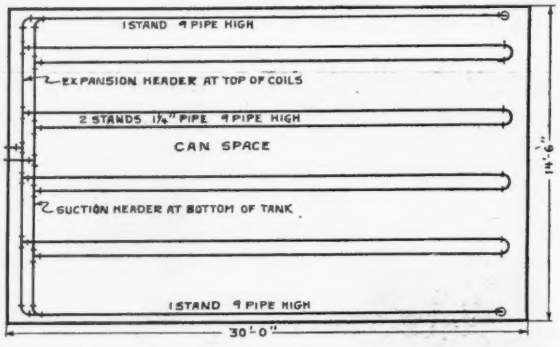
Makers of water turbines now use rubber instead of lignum-vitae for the guide bearings, which is evidence of its anti-friction qualities when wet.

Long Beach, Calif. E. J. JORDAN.



Use of Freezing Tank as Ammonia Condenser

SKETCH of freezing tank herewith is that of one installed a long time ago in our plant for use originally with an absorption machine. The absorption system has been replaced by a compression system. Two 20-t. steam driven ammonia compressors and one 30-t. motor driven compressor have been installed. The discharge


1 STAND 9 PIPE HIGH
EXPANSION HEADER AT TOP OF COILS
2 STANDS 1¼" PIPE 9 PIPE HIGH
CAN SPACE
SUCTION HEADER AT BOTTOM OF TANK
1 STAND 9 PIPE HIGH
14'-6"
30'-0"

CONVERSION OF AN ABSORPTION SYSTEM FREEZING TANK INTO A COMPRESSION SYSTEM AMMONIA CONDENSER

pipes on the 20-t. compressors are 2½ in. in diameter and that on the 30-t. is 3 in. The tank is 14 ft. 6 in. wide by 30 ft. long and holds 143 cans. In this tank there are 3240 ft. of 1¼-in. pipe, which is in good condition, with a 9 high row of pipe between each two rows of cans and with a 2-in. header at the bottom and end for a suction line, which is reduced to 1¼ in. at the tank coils. The top header which was formerly the expansion line is connected by ½-in. connections to the top of the coils.

The compressors and liquid receiver are 200 ft. from the tank. The latter is an upright tank whose lower end is on a level with the top of the freezing tank. The discharge pressure is 160 lb. and the suction pressure 30 lb.

Expression of the opinions of the readers as to the advisability or disadvantage of using the above mentioned tank for a condenser for our two compressors would be appreciated. L. A.

Comments of our readers are solicited. Editor.

Bumped Heads for Pressure Drums

IN THE November 15 issue of Power Plant Engineering you have an article under Questions and Answers about "Bumped Heads for Pressure Drums." Someone inquires about the advantages of riveting the heads inside of the drums or outside of the drums, and the answer is that there is no material difference in the strength of the head as a dished plate. This answer is erroneous as is apparent from the following reasoning.

Pressure drums are ordinarily measured on the inside diameter and if it would happen to be a 48-in. diameter drum, operated under 350 lb. pressure, as was considered in that case, the shearing stress of the rivets will be 14½ per cent greater on account of the larger area that is subject to the internal pressure. This difference springs up on account of the fact that if the head is riveted on the inside of the drum the area subjected to pressure corresponds to only 48 in., while if the head is riveted on the outside of the drum the area subjected to pressure corresponds to 51⅜ in. based on 1¼ in. thick boiler plating. This difference in exposed surface accounts for quite a considerable increase in the shear stress of the rivets and for the case mentioned amounts to about 14½ per cent. This difference will vary with the diameter of the drum; it becomes greater as the drum increases in diameter.

All other things aside, it is for this reason more economical to construct the heads projected inside of the drums.

Erie, Pa. J. EKLUND.

SO_2 as a Refrigerant

WHY IS sulphur dioxide used as a refrigerant and what principle is involved in its use in mechanical refrigeration? H. E. B.

A. Sulphur dioxide was adopted as a refrigerant because it is not as destructive of products being refrigerated, in case of leakage, as ammonia and because of the lower working pressures required.

It is used in a compression system in the same manner in which ammonia is used.

It has a characteristic pungent odor. It is deadly pathologically even in relatively small quantities if relief is not immediately obtained. It is an irritating, irrespirable gas, relatively non-toxic as compared to CO_2.

One great objection to SO_2 is its corroding action on iron and steel whenever moisture gets into the system; the combination of water and SO_2 forms sulphuric acid. Otherwise it has practically no injurious effect upon the materials of which a refrigerating system is constructed except a possible effect upon the lubricating oils used. It has, to some extent, self-lubricating qualities. Certain kinds of petroleum oils absorb it resulting in the dissolving out of certain constituents.

Its density of liquid compared to water as unity is 1.4601 and its gas weighs 2.9267 grams per liter. Its boiling point at one atmosphere is 14 deg. F. Its critical temperature 314.82 deg. F. and critical pressure 1141.5 lb. per sq. in. absolute. Its specific heat at constant pressure is 0.1511 and its latent heat of vaporiza-

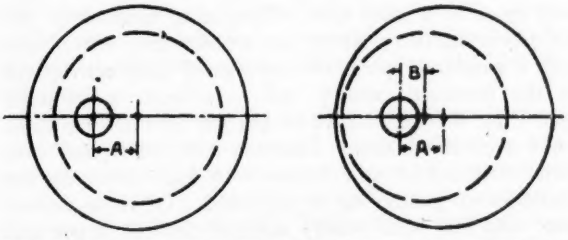
tion at one atmosphere is 172.3 B.t.u. per lb. It is worked at a suction pressure at 5 deg. F. of 11.82 lb. per sq. in. absolute and a condenser pressure at 86 deg. F. of 65.9 lb. per sq. in. absolute.

Pressures with SO_2 are comparatively low as compared with ammonia but the volume of gas to be handled is about four times that required when ammonia is used hence the size of the compressor will be relatively larger and large return mains are required.

Change of Eccentric Sheave Diameter Alters Throw

DOES IT ALTER the throw of an eccentric to take off an inch of the outside diameter after the eccentric has been bored for the shaft? T. J. L.

A. There will be no change in throw if the relation between the center of the eccentric and the center of the shaft is unchanged. This is shown at A in illustration. The distance between these centers is the throw of the eccentric.



THROW OF ECCENTRIC DEPENDS ONLY UPON CENTER TO CENTER DISTANCE OF CRANK AND ECCENTRIC

If, in turning down the eccentric, it is set in the lathe "off center," that is so that it will not run true around its center, the throw will be reduced as shown at B.

Leaks in Back Arches Prevented by Use of Asbestos Plaster

COMMENTING on your answer regarding the use of bumped heads on pressure drums, published on page 1209 of the November 15 issue, I have charge of three 72-in. by 18-ft. h.r.t. boilers with bumped heads to which I have found it difficult to fit back arches.

Occasionally a dozen or more tubes leaked and it was hard to account for the cause. Since we were burning mill refuse and had plenty of it, there was no object in saving fuel. We were not particular either if a brick dropped away, now and then, from the back arch, admitting cold air.

Recently I have found that I could keep the back arch tight by the use of asbestos plaster and I find, since using this plaster, that the tubes leak much less than before.

Gladstone, Mich. PETER BURKARD.

Locating Barometers for Pressure Measurement

IN VACUUM determinations, the barometer should be placed adjacent to the vacuum columns or U gages. This is in contradiction to a statement in the November 1 issue in the answer to the question of J. E. C.

There are two primary methods of vacuum determination. The first is by an absolute pressure gage. In this case, the location of the barometer would be immaterial. An absolute pressure gage is not very popular, due to the extreme care necessary in handling owing to the danger of air getting into the closed end. It should never be used unless there are several, giving a good cross check.

The common method of vacuum measurement is by comparison of readings between a "U" gage or single mercury column connected to the condenser or vessel under partial vacuum and a barometer. Fundamentally, the vacuum gage indicates the differential pressure between the condenser connection and air pressure at the gage. The barometer, located alongside would indicate the absolute pressure at the gage and the differences would thus be the true absolute pressure in inches of mercury at the temperature of the columns.

There are a number of factors, each one of which should make it imperative, for accurate readings, to locate the two instruments together. Pressure differences occasionally do occur. Each inch of water difference in atmospheric pressure between the vacuum gage and barometer would entail an error of approximately 0.074 in. of mercury. Temperature differences are a big factor as 10 deg. F. difference will mean an error of approximately 0.025 in. mercury. If the two instruments be located at various altitudes there will be an error of 0.01 in. of mercury for each 10 ft. difference. Evidently, unless corrections are to be made or errors ignored, it is essential that the two instruments be located in close proximity.

Denver, Colo. C. H. HOPER.

Gasket in Air Pump Causes Trouble

IN OUR PLANT, an old air pump whose main valve is operated by steam, constantly gives trouble by stopping at one end of its stroke. The steam is admitted to the opposite ends of the main valve by a small auxiliary valve which is operated by an arm on the main rod striking tappets at each end of the stroke. When the piston is moving from the steam end to the water end it moves very slowly. All of the parts between the auxiliary valve and main valve seem to be clear. What is causing the trouble? H. W. H.

A. In most cases where pumps having steam operated valves stop at the end of the stroke, the cause is found in the gaskets covering the port. The gasket should be inspected and that portion which overlaps trimmed off.

Comparative Heating Values of Coke Fuels

WHAT IS the difference between hard or gas factory coke and common soft coke? What are their heating values? G. A. P.

A. The heating value of gas coke varies from 8681 to 13,790 B.t.u. per lb. while oven coke varies from 12,240 to 14,562.

Comparing coke from a single region such as West Virginia, the average values are:

Gas coke—dry	12,625 B.t.u.
Gas coke—as received	9,600 B.t.u.
Oven coke	14,450 B.t.u.

EDITORIAL COMMENT

Electrification of the Coal Fields

Electrification of the coal fields is rapidly taking place in spite of the fact that the coal mining industry, like the railroads, is always hesitant about adopting new ideas and methods.

Tremendous standby losses due to load conditions and the necessity of replacing old power generating equipment with new modern machinery in order to have competitive operating costs have driven many mine operators to central station power. Even where the necessity of heavy investments for a private plant is not involved, central station power is often advisable and the number of mines that have electrified in certain fields, such as the Illinois field, is remarkable, having virtually driven out the small isolated plant.

This load works in well with the domestic load as the mine load drops off early in the afternoon, just about the time the domestic load starts to go up. The extent to which electricity has been adopted in the bituminous coal fields is brought out by recent statistics. Eighty-eight per cent of the total output of bituminous coal comes from mines using underground locomotives. There are in use 14,723 locomotives, 98 per cent of them electric, as compared to 37,000 animals. It is said that there are 1512 mines using locomotives exclusively for hauling.

Although electric ventilating systems, coal hoists, undercutters and other machines are not in as widespread use as machinery in some other industries, they are coming into general use and are adding to the production of the mines and lowering production costs where the output is sufficient to pay for the investment. It is a load which some of the power companies had the foresight to go after and get in spite of apparently overwhelming odds.

At first glance it does seem hopeless to buy coal, transport it to a central station, burn it to make power and send the power back many miles over transmission lines and sell it to the mine cheaper than the mine itself could produce the power on unbelievably cheap fuel. That it is not only possible but profitable to both parties has been proven beyond a doubt.

Higher Pressures and Temperatures

If we consider the central station field as a whole there are three pressures which appear to stand out and dominate the entire industry. Roughly they are 400, 600 and 1200 lb. These, of course, are but approximate values, individual cases varying a few pounds one way or the other. In other words, there are three distinct schools and from present and contemplated construction each school is apparently convinced that the pressure they have adopted is the most economical one.

Going deeper into the subject, it is evident that local conditions are the major factor in determining what pressure is the most economical to use for a given installation and that each of the three schools is justified in its choice in spite of the fact that they disagree with the others. In other words the load factor and first cost will vary with location and industrial conditions, so in order to choose wisely it is necessary to look into the future to predict what may be expected in the next ten years. This is, of course, a gamble, although predictions from certain districts with a stable background can be considered more reliable than others.

There are other minor factors to be considered. For instance, the 400 lb. pressure is well adapted to the superimposition of a high pressure steam cycle or mercury cycle at a later date. Then also, fortunately for the power industry, there are certain individuals who with a gambling spirit, the courage of their convictions or the foresight, ability and experience to visualize something beyond that which has yet been accomplished make a great advance. Lakeside with pulverized coal, Philo with reheat and Edgar with high pressures are examples of pioneering of this kind. Of these pulverized coal has been widely adopted for all types and sizes of plants; reheat, although used extensively by those who first adopted it, has not been enthusiastically received by other companies, while the fate of higher pressures is still to be decided.

Perhaps the most concise explanation of the economic selection of pressures is found in a discussion by F. J. Vandeventer before the A. S. M. E. Fuels Meeting at St. Louis, in connection with a proposed central station, starting out the first year with one hundred thousand kilowatts of installed capacity and increasing in the tenth year to roughly three hundred thousand kilowatts installed capacity. An analysis was made rather carefully to compare the relative merits of 150, 350, 600 and 1200 lb. operating pressure.

An analysis was made by considering each for the first ten years of the life of the plant, by setting up an investment sheet and an anticipated load curve for each year. Then operating sheets were set up on the anticipated load curve and the fuel costs for the ten years were obtained and totalized.

It was found that if 600 lb. were used, a saving, in ten years' time, of one million dollars worth of fuel would be affected, as compared with three hundred and fifty installation. But then, going back to the investment and fixed charge tabulation, it was found that the summation of fixed charges over ten years, for the six hundred-pound set-up, would exceed by two million dollars the fixed charges on the three hundred and fifty pound set-up. By adopting the higher pressure, one hundred thousand dollars worth of fuel would be saved each year, at the expense of two hundred thousand dollars' worth of fixed charges. Naturally, the 350-lb. cycle was adopted for the station.

That does not mean that 600-lb. pressure does not

have its place, or that 1200-lb. does not have. The capacity use factor over the 10-yr. period was 56 per cent, and the fuel cost was $2.35. Naturally, if the fuel cost had been $4.70, then the fuel saving would be two million dollars, and the additional fixed charge would be two million dollars, and the two systems would be on a par. Furthermore, if the load factor were increased from 56 per cent to some higher factor, then the two systems would be more nearly equal to one another. Similarly, if you have a combination of a somewhat higher fuel cost, and a somewhat higher load factor, they would equalize again.

That the higher pressures, that is, 1000 to 1500 lb. are practical has been proved beyond a doubt and that it has proven economical is indicated by the fact that a 10,000-kw. turbine with two 1400-lb. boilers is being added at Edgar station after about two years' operation of a trial 3000-kw., 1200-lb. installation. At Lakeside over a considerable period of time the 1200-lb. turbine with its complement of 300 lb. capacity generated 33 per cent of the station output and an increase of about 3 per cent in station efficiency was experienced. From heat balance and tests it is estimated that the 1200-lb. unit is 10 per cent more efficient than the 300-lb. equipment.

In the development of these high pressure units there has been a noticeable absence of serious difficulties and the manufacturers of the main equipment and auxiliaries have lost no time in attacking and solving the problems that have been encountered. Today the manufacturers stand ready to supply practically any demands that may come up within the maximum limit of 800 deg. F. At least one manufacturer of fittings has announced a maximum temperature limit of 1000 deg. F. so that a decided increase in operating temperatures and facts regarding the commercial mercury-steam cycle are the two developments which we may look forward to for further gains in efficiency.

Off Duty

A billionth of an inch isn't anything to be greatly concerned about. Even when buying a yardstick, that is if anybody ever really buys a yardstick, you found when you arrived home that it was a billionth of an inch too long or too short, the chances are that instead of going back and raising a howl about it, you would ignore the matter. A billionth of an inch after all is a small matter, and life's too short to worry about trifles.

At the Bell Telephone Laboratories in New York City they think differently, however. Life there is concerned largely with trifles—important trifles—and since even a billionth of an inch is a matter of consequence with them, they recently devised a means for measuring such small orders of length.

Now, a billionth of an inch as we have asserted, isn't a great deal. As a matter of fact, such a length is about one-tenth the distance between the atoms of most metals. A million such lengths, placed end to end would not be as thick as a fairy's wings.

Several years ago on this page we referred to the ultra-micrometer, a device capable of measuring to the millionth part of an inch. At that time the scientists were quite tickled at having found so short a rule and everybody took it for granted that a millionth of an inch was the ultimate in smallness.

At the Bell Telephone Laboratories, however, they are an ambitious lot, and to them a millionth of an inch was too large to bother with, so they undertook to devise a rule with billionth of an inch markings. A lot of foolishness? Well, perhaps to some people's way of looking at it, it is, but many things look foolish when not entirely understood. To the American Telephone and Telegraph Co. it didn't seem foolish, in fact the need for so refined an instrument arose from studies of magnetic material, a subject of greatest importance to this company because magnetism plays an essential part in all forms of electrical communication. For years it had been assumed that pure iron was the best magnetic material. The recent discovery by G. W. Elmen of the Bell Laboratories, of permalloy, a material used in the new transatlantic cables and which is a far better magnetic material than iron called for an explanation.

The task of supplying this explanation was undertaken by Dr. L. W. McKeehan of the Laboratories technical staff. He felt that the secret lay in the amount of expansion or contraction that a metal undergoes when it is magnetized. Magnetization ordinarily is accompanied by the production of heat and since the amount of this heat varies for different alloys it was surmised that the heat loss was closely connected with the change in length. This it was determined to verify.

To carry on this investigation it became necessary to have a measuring instrument of greater delicacy than any in existence. This equipment, developed by P. P. Cioffi of the laboratories' staff, is designed to measure changes in length of a piece of wire about four inches long and is sensitive to variations in length of the order of a billionth of an inch. As imperceptible temperature changes cause expansion far greater than the changes in length to be measured, every precaution is taken to keep the temperature of the wire constant. It is surrounded by a vacuum cylinder like a thermos bottle with an opening at each end and in addition a special electrical compensating coil is used to maintain constant temperature. The entire equipment is mounted on a spring suspension so that building vibrations will not affect it.

A billionth of an inch! A billionth of a degree of temperature! What, after all, is astonishing about these things other than the sound of the words? Are these units any different from the light year used by the astronomer? One is measured, perhaps, as easily as the other. Our ability to measure things is only limited by our knowledge of things. When the earth was the center of the universe and the sun and moon and stars fixed permanently in crystal spheres surrounding the earth, it was obviously as impossible to measure light years as it was to measure the distances between atoms when matter was thought to be continuous.

So the development of a means for measuring a billionth of an inch is not so much an achievement in our ability to construct delicate mechanical contrivances as it is an extension to our absolute knowledge of things. Skillful work has been done in all ages, but the most skillful hands in the world could not construct a device for measuring a change of length of a billionth of an inch unless the mechanism underlying such changes in length are understood.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Jeffrey New Portable Scraper

DRAG-ON is the name given this new equipment for handling coal and coke in power and industrial plants.

Reduced weight is obtained by lightening the frame and using a shorter mast although working and wearing parts are made stronger. Flights and bottom plates at the loading end are of ¼-in. steel. The screening chute is 3 ft. long with 6 sq. ft. of mesh, welded from round bars. Wheels are 4 ft. diam. on 3-in. tires and swiveled to turn in either direction, giving the Drag-On a complete circle of action around a fixed loading point.

DRAG-ON PORTABLE SCRAPER CONVEYOR

Power is supplied by an electric motor running on ball or on roller bearings. To raise or lower the discharge end, a worm-geared winch actuates a cable over the top of the mast, all bearings being pressure-lubricated by means of a grease gun.

Segment Roll Coal Pulverizer

IN THE pulverizing of granular material, four principles have been used, namely, pressure, impact, attrition and free discharge of the finished product. By the Brainard segment roll pulverizer, combination of these elements has been employed, as indicated in Fig. 1.

Bull ring D, revolving at slow speed in the direction indicated by the arrow carries with it the loose segments A, B and C. Starting at the position shown, segment A riding down on the surface of C, effects attrition between these two elements, which is followed by crushing action when the surface of A strikes on that of B. This will be followed by attrition between the surfaces of A and B as the former slides out toward the bull ring and also between the surface of A and the bull ring surface during revolution. At the same time there will be attrition between the surfaces of C and B

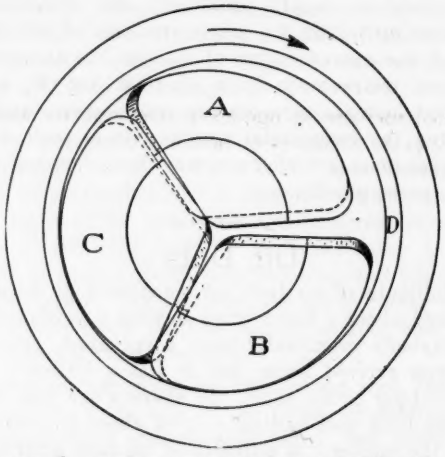


FIG. 1. DETAIL OF PULVERIZING ELEMENT

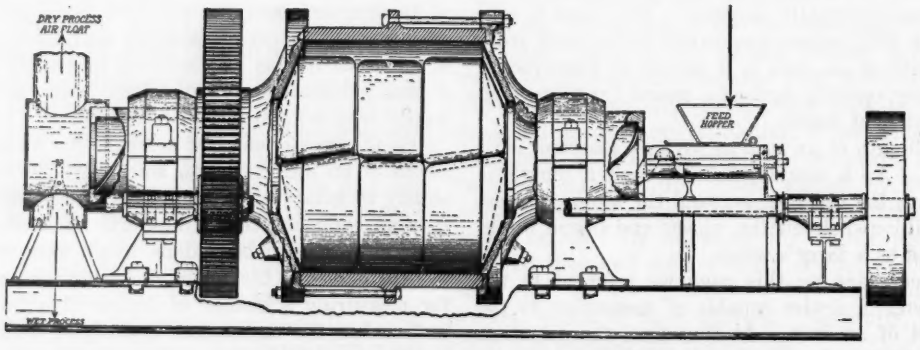


FIG. 2. SECTION OF TRIPLE ROLL PULVERIZER

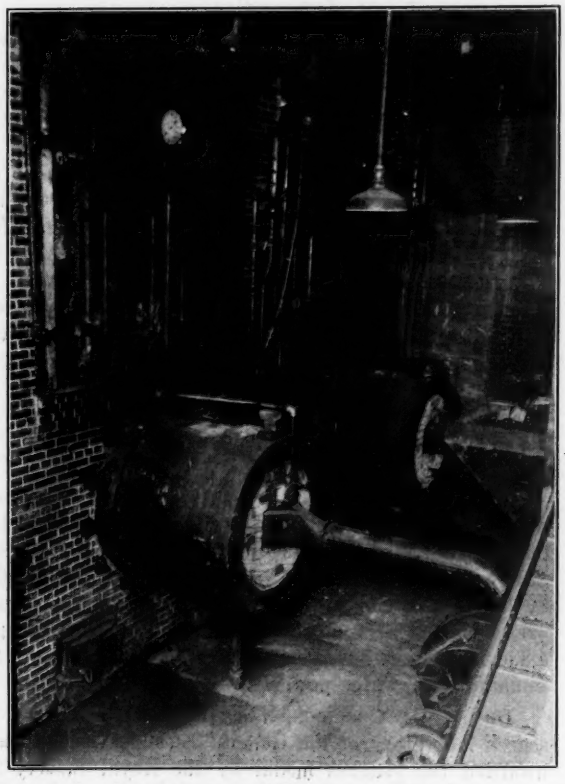
and between the surfaces of these two segments and the bullring. The operation of A is repeated by each segment in turn as the system revolves, so that the combined action of attrition, crushing and the jarring loose of adhering particles is continuous.

As shown in Fig. 2, material is supplied to a feed hopper, thence through a hollow shaft to the pulverizing section and is swept away again through a hollow shaft by air currents to the discharge chamber whence it can be carried away either by the air float dry process, or by wet process, as may be desired. The machine runs at slow speed, and can be operated to give either coarse or very fine product from any kind of fuel.

It will be noted that the design is such that the machine is self-contained, that none of the bearings is subjected to dust and that wearing parts are easily accessible. The device is made by the Brainard Pulverizer Co., Old Colony Bldg., Chicago, Ill.

Pulverized Fuel Extension Furnace for Small Boilers

ERIE CITY IRON WORKS has recently placed on the market a simple extension furnace which may be attached to the front end of a low setting boiler to provide the necessary increase in combustion space required for the burning of pulverized coal, thus providing, at small expense, a means for readily adapting pulverized fuel burning to small installations.

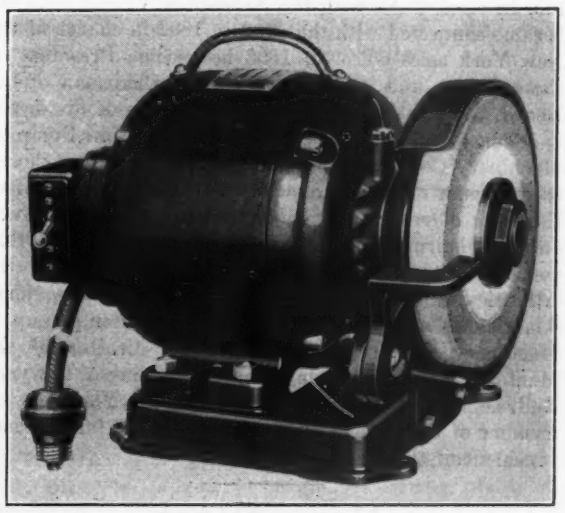


ATTACHABLE FURNACE EXTENSION PROVIDES MEANS FOR BURNING PULVERIZED COAL UNDER LOW SETTING BOILERS

This "Vortex" furnace, as it is called, consists essentially of a cylindrical refractory lined combustion chamber in which preheated air and turbulence combine to complete combustion before the flame hits the cold surfaces back in the furnace.

Master Motor Grinder

DESIGNED FOR miscellaneous small power drives in addition to its grinding wheel, the Master motor grinder has recently been placed on the market. It is intended for temporary small drives around the shop or power plant, for light grinding and other uses that will readily suggest themselves. The motor is either a type SA, ¼-hp., split phase motor for 110 v. or a type DM d.c. motor for 32, 115 or 230 v. The unit is furnished with pulley adapter, grinding wheel and guard, cord and adjustable tool rest and motor base. It is manufactured by The Master Electric Co., Linden and Master Avenues, Dayton, Ohio.



PORTABLE GRINDER HAS GROOVED PULLEY FOR DRIVING ANOTHER MACHINE

CONSUMERS' STOCKS of bituminous coal amounted to 61,900,000 t. on October 1, according to a survey just completed by the United States Bureau of Mines, Department of Commerce. In comparison with the final revised figures for July 1—63,400,000 t.—this is a decrease of 1,500,000 t. On October 1, 1926, the stocks were 43,000,000 t.

Exports during the third quarter of the year were normal, averaging 351,000 t. a week. Home consumption averaged 8,360,000 t., as against 9,050,000 t. in the same period last year, the decrease of 7.6 per cent reflecting diminished activity in the steel, automobile and other industries. With colder weather, however, the weekly consumption tends to increase and in the last quarter of 1926 it averaged 11,200,000 t.

In addition to the stocks of consumers there were 9,905,547 t. of bituminous coal on the docks of Lakes Superior and Michigan.

Stocks of anthracite are fully up to normal for this season of the year.

E. H. Wells Dies

AFTER SEVERAL months of ill health, Mr. Edward Hubbard Wells, Chairman of the Board of Directors of the Babcock & Wilcox Company of New York, died at his home in Montclair, N. J.

Mr. Wells was born in Dorrville, R. I., and was 69 yr. of age at the time of his death. His earliest adult work was with the Keystone Construction Co. of Pittsburgh. His work as general manager of this concern dealt largely with the installation of central stations in the early days of the electrical industry and brought him in close touch with the Babcock & Wilcox Co. He became connected with that firm in 1892 in charge of the New York sales office, in 1898 he became President of the company and in 1919 was elected Chairman of the Board, the position he held until the time of his death.

Some years ago when the Worthington Pump & Machinery Corp. was reorganized, Mr. Wells was chosen as chairman of the reorganization committee and, after the work of reorganization had been completed, he was elected chairman of the executive committee of that corporation. Mr. Wells was also a chairman of the Atlantic Mutual Insurance Co., director of the North American Co., director of the Worthington Pump & Machinery Corp., all of New York, director of the Montclair Trust Co., member of the Engineers, Lawyers, Railroads, and Automobile clubs of New York City, a member of the Essex County Country Club, and former president of the Montclair Golf Club.

News Notes

THE ROCKFORD, Ill., Chapter, American Society of Steel Treating, recently began a series of six lectures given by John F. Keller, steel specialist from Purdue University and the first class was attended by 70. It was indicated that at least 20 more would enroll before the second lecture of the course. The Illinois series followed a four years' course in Indiana, each covering six weeks, which enrolled 3600 metal trades workers from 500 industries.

RESUME OF experiments which led the production of coke from Illinois coal, impressions of industrial activities in Russia, discussion of professional ethics and field trips of value marked the Middle West meeting of members of the American Institute of Mining and Metallurgical Engineers in Danville and Urbana, Ill., Nov. 11 and 12. The sessions, which included 150 members of the Chicago and St. Louis sections, began in Danville, where various industrial plants were inspected and concluded at a banquet in the Hotel Wolford in the evening. Prof. S. W. Parr of the University of Illinois, discussing "Low Temperature Carbonization of High Oxygen Coals," related the experiments which resulted in the successful manufacture of coke from Illinois coal; Prof. A. C. Noe of the University of Chicago told of his Russia trip and Dean Milo Ketchum of the University of Illinois described some of the experimental work being conducted at the University through cooperation of various industries. Later the group went to Urbana where the University of Illinois mining engineering and foundry laboratory were viewed, the state geological office and laboratory inspected and Prof. Parr's coking plant viewed.

OFFICIAL ANNOUNCEMENT comes from Carnegie Institute of Technology, Pittsburgh, Pa., that a second International Conference on Bituminous Coal will be held there during the week of November 19, 1928. Decision to call a second congress of world scientists and fuel technologists has been made as a result of the widespread interest aroused throughout the world by the first conference on bituminous coal held at Carnegie in November, 1926. The first conference, devoted to discussions of the better utilization of bituminous coal, was attended by 1700 people, including delegates from 13 different countries. Distinguished European and American scientists took part in the conference.

Although no definite plans have been made for the second conference, it is expected that this will cover the latest developments in low and high temperature distillation processes, smokeless fuel, utilization of coal tar products and other timely subjects.

IN A RECENT reorganization of the Indiana Public Utility Association, William Stokes has become secretary and manager, to succeed John C. Mellett. New offices for the Association have been established at 1547 Consolidated Building, Indianapolis, Ind. Officers of the Public Utility Association for the current year are: Arthur W. Brady, Union Traction Co., Anderson, president, and H. S. Morse, general manager, Indianapolis Water Co., treasurer. C. L. Kirk, manager, Citizens Gas Co., Indianapolis, is chairman of the Committee on Public Utility Information.

ANNUAL REPORT of the Federal Power Commission shows 77 new applications filed during the last fiscal year, 64 for licenses and 13 from those who have held preliminary permits to develop water powers. Total power involved is 3,300,000 hp., two projects being of large size. These are the New River development of the Appalachian Electric Power Co., for 100,000 hp. and the project of the Savannah River Electric Co. for 120,000 hp.

Developments started during the year are 31 in number with capacity of 362,000 hp., the two largest being the Carolina Power & Light Co.'s Pigeon River plant of 105,000 hp., and Chelan Electric Co.'s project at Lake Chelan, Washington, of 110,000 hp.

Total projects completed or under construction at the close of the year are 128 with aggregate power of 4,610,000 hp.

ACCORDING TO the latest report from the Geological Survey, Department of the Interior, production of electric power by public utility power plants in the United States for September reached a total of 6,559,840,000 kw-hr. in September, 1927, an increase of 5 per cent over that for September, 1926. Of this total amount, 4,336,586,000 kw-hr. were generated by fuel and the remainder by water power.

DR. W. D. COOLIDGE, assistant director of the research laboratory of the General Electric Co., has been awarded the Hughes medal by the Royal Society for "distinguished work on X-rays and the development of highly efficient apparatus for their production." The Hughes medal was first presented in 1913 to Dr. Alexander Graham Bell. Dr. Irving Langmuir, also of the General Electric research laboratory, received it in 1918.

WHITING CORP., Harvey, Ill., has elected A. H. McDougall as vice-president and director of sales, effective

November 11. Since 1903 Mr. McDougall has been with the Whiting Corp. in various capacities, among them being those of chief engineer, vice-president and consulting engineer. He is a graduate of the University of Michigan, class of '01, and member A. S. C. E. and A. S. M. E.

READING IRON CO., Reading, Pa., has appointed L. J. Melson to the position of District Sales Representative in the Cincinnati office, 618 Dixie Terminal Bldg., Cincinnati, Ohio.

STONE & WEBSTER, INC., Boston, Mass., announces that Stanley Brown, formerly with McClellan & Junkersfeld, Inc., and Dwight P. Robinson & Co., Inc., has joined the electrical division of Stone & Webster.

AT GRAND HAVEN, Mich., Municipal Electric Light & Water Dept. is spending about $60,000 for an addition to the light plant. Practically all the equipment except the coal handling conveyors have been purchased. The boiler equipment will consist of a 500 hp. Stirling boiler fired by Westinghouse multiple retort stokers. A Zeolite water system will be installed for treating feed water.

In addition to this they are spending about $115,000 for a filtration plant which they expect to install and have in service sometime the early part of next spring.

TEN PROPERTIES of the Central Cities Utilities Co. in Iowa, Illinois, Nebraska, South Dakota and Kansas have been acquired by the Great Lakes Utilities Co. which is serving communities in nine states. The Central Cities Co. headquarters are in Newton, Iowa, and its plants involved in the transfer were located in Rochelle, Paxton and Rantoul, Ill.; Scottbluffs, Fairbury and Gering, Nebr., Watertown, S. D., Concordia, Kans., and LeMars and Chariton, Iowa.

INSPECTION was recently made of the new 35,000-kw. turbine generator unit of the Binghamton Light, Heat & Power Co. and of the arrangements for transmitting this energy over a 110,000-v. line to Elmira. Some eight hundred business men and officials of the various communities served by the company attended the inspection at the main power station, Johnson City, N. Y., and were shown the complete plant from coal pile through pulverizing equipment, boiler room and generating equipment up to the substation which steps up from 33,000 v. to 110,000 v.

DEVELOPMENTS contemplated by the West Texas Utilities Co. and its sister organization Central Power & Light Co. include enlargement of the San Angelo plant to 16,000 hp., installation of at least a first 2500-hp. unit on Devil's River, 16 mi. northwest of Del Rio and of an 800-kw. generator driven by De Lavergne oil engine. Extra power is needed for operation of the 400-mi. pipe line from the Yates field in Pecos Co. to tidewater at Houston, the West Texas Co. furnishing power to the Val Verde Co. line and Central Power & Light Co. the balance of the way. Interconnection of the companies' systems will be made at the county line, involving the building of 154 mi. of transmission line by the latter company and 60 mi. by the former. Also the Central Power & Light Co. will build 10 pumping stations of 400 hp. each along the pipe line and two more dams will be built farther up Devil's River for storage and for development later of additional power.

FACTORY UNITS of the Herman Nelson Corp., Moline, Ill., manufacturers of heating and ventilating devices, will be concentrated in one site when factory expansions, announced recently by Herman W. Nelson, president of the company, are completed at a cost of $150,000.

TO INCREASE FACILITIES for carrying on consulting engineering work, the Neblett Engineering Co. has been incorporated by Wilfred Sykes and his associate, H. W. Neblett of Chicago. The new company will have offices at 100 W. Monroe St., Chicago, and will retain the organization formerly used in its work. The only change is in the form of the organization.

C. I. CARLSON AND W. J. MURDOCK of the Western United Gas and Electric Co. properties in Joliet have been promoted by the company, Mr. Carlson, after 10 yr. as general manager of the Joliet district, being made general manager of the Aurora district and Mr. Murdock, superintendent of the Coal Products Co., a branch of the Western United, succeeding Mr. Murdock in the Joliet district.

THE IOWA ELECTRIC CO., operating a chain of gas and electric plants through Iowa, is negotiating with the Muscatine, Iowa, city council to present application for the 25-yr. gas franchise for that city when the present contract with the Muscatine Lighting company expires in 1929.

THE HOUSTON LIGHTING & POWER CO., Houston, Tex., plans to expand its steam generating plants at Deepwater to increase the capacity by about 40,000 kw.

CONTRACT has been awarded to the McIntosh & Seymour Co. of Auburn, N. Y., for three marine Diesel engines to be installed in the U. S. Shipping Board ships Courageous, Defiance and Triumph. Overhauling of these ships is to be done by the Federal Shipbuilding Co., the Norfolk Navy Yard and the Boston Navy Yard, respectively.

Books and Catalogs

COMBUSTION. American Gas Association, 342 Madison Ave., New York. Price $3.00; members, $1.50.

Prepared under the direction of the Industrial Gas Section of the American Gas Association, this reference book on the theory and practice of the principles of combustion is particularly well prepared and contains data on all phases of gas combustion, both from the standpoint of the theoretical, operating and designing engineer.

Chapters are headed "Heat and its Measurement," "Correction for Temperature and Pressure," "Chemistry of Combustion," "Calorimetry," "Thermal Capacity," "Flame Temperature," "Analysis of Furnace Gases," "Recuperation and Regeneration," "Factors Affecting the Efficiency of Utilization of Gaseous Fuels" and "Fuel Comparisons." A bibliography and index are included.

RECENTLY a complete analysis of pipe line problems was made under the title, "A Physical Study of the Mokelumne Pipe Line," by Lloyd T. Jones and Walter S. Weeks, published as paper number 9, volume 2 of the University of California Publications in Engineering.

It can be obtained from the Manager of the University Press, Berkeley, Calif., for $1.

This pipe line contains about 80 miles of steel pipe and the necessary amount of cement-lined tunnel to carry water from the Mokelumne River 90 miles to the water reservoirs of Oakland and Berkeley, Calif. Calculations and methods of calculations regarding anchorage measurement and resistance have been made from pipe line stresses, both for the operating stresses due to water pressures, temperatures and construction stresses. Stresses due to welding, gravity and differential temperatures have been measured and analyzed.

Programs for laying, welding and backfilling of pipe are covered and the metallography and composition of the welds, effect of carbon and normalizing in the field are discussed in considerable detail. The paper is in effect a complete study of the pipe line problem from every conceivable angle.

It is said to be the first and only treatise on pipe line stresses and is published for those interested in pipe line construction, particularly for welded lines.

FOSTER WHEELER CORP., 165 Broadway, New York, has just issued bulletin 120, a 12-page illustrated booklet dealing with Wheeler feed water heaters. This contains data on heater design and construction with photographs of installations. In Bulletin EC-102 the Foster economizer is completely described and illustrated. This takes up general fundamental principles of economizer design, discusses the details of the Foster economizer and shows how it is fitted into the heat balance scheme and the boiler arrangements of various well known installations. In bulletin 119 hot water heating systems of the forced circulation type are described.

THE KENNEDY VALVE MFG. CO., Elmira, N. Y., to commemorate its 50th anniversary, has just issued an illustrated 24-page brochure in colors describing the development of the company and discussing in a general way the characteristics of Kennedy valves and the methods of manufacturing them.

THE PHILIP CAREY CO., Cincinnati, Ohio, in bulletin 101-A, just issued, discusses heat insulation for temperatures from 500 deg. F. to 1200 deg. F.

G. H. WILLIAMS CO., Erie Pa., has issued a 32-page bulletin describing and illustrating Williams fast digging clamshell buckets.

THE HUBAR-JONES CORP., 13 Astor Pl., New York City, in a recent bulletin describes the Godfrey oxygen jet cutting machine.

SARCO CO., INC., 183 Madison Ave., New York City, has issued a leaflet on Sarco heavy service steam traps.

AMERICAN SPIRAL PIPE WORKS is issuing a chart for determining stresses in and the design of plain ring flanges and high or low hub forged steel flanges. These incorporate the results of tests on actual stresses and development of formulas by Professor E. O. Waters of Yale University. Use of the chart is entirely graphical. Copies may be obtained from the above named company, Box 485, Chicago, Ill.

DAMPNEY CO. OF AMERICA, Hyde Park, Boston, Mass., reprints in its bulletin 1133 the report of tests on heat transfer between steam and water for bare pipe and for pipe with one to four coats of Apexior composition. These tests were made by the National Physical Laboratory at London, England. They show that, with the coating, heat transfer is increased to a considerable extent. Method of calculating the coefficient of heat transmission is given in an appendix. Copies of the report can be had from the Dampney Co. of America.

THE ADSCO ADVOCATE, Volume 1, No. 5, published by American District Steam Co., North Tonawanda, N. Y., contains an interesting article on the golden anniversary of district heating, together with considerable data on the lives and works of Birdsill Holly and John D. Walsh, who were responsible for its early development.

CENTRIFUGAL BLOWERS and compressors for blast furnace, steel plant and by-product coke oven service; also pumps, turbines and speed reducers are described in Bulletin E-1107, issued by DeLaval Steam Turbine Co. of Trenton, N. J. Blowers and compressors are described for single stage and multi-stage type capable of bearing pressures up to 100 lb. per sq. in. They are motor or steam turbine driven, and the construction, as well as many installations embodying this equipment are clearly shown in the bulletin.

WALWORTH CO., Box 26, Boston, Mass., describes the complete line of Walworth brass valves in a 32-page illustrated booklet just issued. These are shown in all types for working steam pressures from 125 to 300 lb.

CELITE PRODUCTS CO., Los Angeles, Calif., has issued a 16-page illustrated booklet on high temperature insulation. This gives engineering data on the design of such insulation and shows installations of Sil-O-Cel for this purpose.

AMERICAN BLOWER CO., Detroit, Mich., has just issued bulletin No. 1124 on collecting fly-ash and coal dust. This describes the new Sirocco collector and shows many interesting installation photographs.

HILLS-MCCANNA CO., 2345-59 Nelson St., Chicago, Ill., has issued an illustrated colored folder calling attention to Hills-McCanna alloys for special purposes.

SUPERIOR GAS ENGINE CO., Springfield, Ohio, has just issued Bulletin 114, describing and illustrating Superior-Otto Diesel engines manufactured by this company and the Otto Engine Works, Philadelphia, Pa. These are of the 4-cycle, airless-injection, cold-starting type in sizes from 60 to 360 hp.

STOCKHAM cast steel flanged fittings and flanges, made by the Stockham Pipe & Fittings Co., Birmingham, Ala., are described in a book which contains dimensions, pressure and temperature ratings and prices. These fittings are made for ordinary, high and extra high pressures, up to 1350 lb. by the electric furnace method. The book can be had by writing to the company.

FISHER GOVERNOR CO., Marshalltown, Ia., has issued the first edition of its new complete catalog of automatic regulating specialties. This is in loose leaf form, firmly bound in a heavy cardboard cover, with each class of specialties grouped in a separate bulletin, and other bulletins will be added to the collection from time to time. They include bulletins on governors and regulating devices for pumps, reducing valves, pressure regulating devices, liquid level controllers and similar equipment.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Another Year Ends that a Greater Year May Begin

In this, the Annual Review Number of Power Plant Engineering, is shown the progress made in the development of mechanical power.

Sound economics stand behind engineering progress, ready to take advantage of its every advancement. On such advancement new plants are built, new equipment is installed to generate power economically and new ways and machines are worked out to utilize power generally.

Next year's battle will be a battle of the cost sheets, and no trick or turn, no scheme, will take the place of high quality at low costs. These benefits in turn, divided and in part passed on to the general public, create a greater demand, therefore greater prosperity.

Power, heat and light are not only sold directly to ultimate consumers, but they are also basic factors by means of which manufacturers, jobbers, store keepers and practically every other business activity may lower costs, give more service and extend their business in the battle of the cost sheets.

New construction and equipment to the amount of $2,546,069,737 for the first eleven months of this year is an indication of the extent to which the financial and business world takes advantage of improvements in power plant engineering.

Record upon record, as plant after plant is built, shows that mechanical power is being reduced in cost, is increasing in use and is gaining the favor and support of all the people.

The forthcoming January 1, 1928, Annual Reference and Textbook Number on "Power Plant Performance" will assist engineers in the large plants of the country, to obtain better results with the equipment they have, and to obtain the facts about their plants which will enable them to obtain new and better equipment.

January 15, 1928, will be the "Power Plant Equipment" Number. Its editorial contents will cover the types of machinery and equipment that are referred to in the great January 1st Number and will be supplementary to this important number.

Never in the history of power generation have engineers exerted so powerful an influence in the affairs of all mankind and that influence will continue to increase throughout 1928.

The world is shaking itself down into its boots and is realizing that no person, no business, no nation or combination of nations, can stand out against the principles of sound economics.

Manufacturers are pioneering, perfecting and testing equipment for the service of power plant designers and operators.

Those who have something that contributes to the power that drives this great civilization of ours can find their markets by giving the facts to the readers of Power Plant Engineering.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem, Pa.
Binks Spray Equip. Co., Chicago.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner-Denver Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa.
Sullivan Machy. Co., Chicago.
Worthington Pump & Mach. Corp., New York.
Yeomans Bros. Co., Chicago.

AIR COOLERS.
Spray Engineering Co., Boston.

AIR FILTERS
Connor Co., Inc., The W. B., N. Y.
Spray Engineering Co., Boston.

AIR PREHEATERS.
Air Preheater Corp., New York.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., New York, N. Y.
Prat-Daniel Corp., New York.

AIR WASHERS
Buffalo Forge Co., Buffalo, N. Y.
Connor Co., Inc., The W. B., N. Y.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland.
Wright-Austin Co., Detroit.

ANTI-CORROSIVE COATINGS
Dampney Co. of Am., Boston.

ARCHES, BOILER AND COMBUSTION
Brady Conveyors Corp., Chicago.
Carborundum Co., Perth Amboy.
Detrick Co., M. H., Chicago.
Girtanner Engrg. Corp., N. Y.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Hofft Co., M. A., Indianapolis.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.

ASH BIN GATES AND DOORS
Allen-Sherman-Hoff Co., Phila.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., Phila.
Brady Conveyors Corp., Chicago.
Combustion Engrg. Corp., New York, N. Y.
Conveyors Corp. of Am., Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS
Brady Conveyors Corp., Chicago.

BABBITT METAL
Magnolia Metal Co., New York.

BAROMETERS
Taylor Inst. Co., Rochester, N. Y.

BEARING METAL
Magnolia Metal Co., New York.

BEARINGS
National Tube Co., Pittsburgh.

BELT CONVEYORS
Jeffrey Mfg. Co., Columbus.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT DRIVES
Smidth & Co., F. L., New York, N. Y.

BELTING
Crandall Pkg., Palmyra, N. Y.
Quaker City Rubber Co., Phila.

BELTING, SILENT CHAIN
Link-Belt Co., Chicago, Ill.

BLOWERS, FAN & FURNACE
Air-Preheater Corp., New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Prat-Daniel Corp., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Boston, Mass.

BLOWERS, PORTABLE.
Sturtevant Co., B. F., Boston, Mass.

BLOWERS, PORTABLE ELECTRIC.
Breuer Elec. Mfg. Co., Chicago.

BLOWERS, PRESSURE
Carling Turbine Blower Co., Worcester, Mass.

BLOWERS, PULVERIZED COAL
Buffalo Forge Co., Buffalo.

BLOWERS, STEAM
Schutte & Koerting Co., Phila.

BLOWERS, TUBE
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.

BLOWERS, TURBINE
Carling Turbine Blower Co., Worcester, Mass.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES
Boiler Engrg. Co., Newark, N. J.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., N. Y.

BOILER CAP CLEANERS
Lagonda Mfg. Co., Springfield, O.

BOILER COATINGS
Dampney Co. of Am., Boston.

BOILER COMPOUND
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chem. Co., Inc., New York.

BOILER COMPOUND FEEDERS
Hills-McCanna Co., Chicago, Ill.

BOILER ENGINEERS
Boiler Engrg. Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., Inc., New York.
Permutit Co., New York, N. Y.

BOILER FRONTS
McLeod & Henry Co., Troy, N.Y.

BOILER MOUNTINGS
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Insulating Products Corp., N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.

BOILER SETTINGS
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Rust Engrg. Co., Pittsburgh.

BOILER TUBE CLEANERS
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.

BOILER TUBES
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 170

Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS
Botfield Refractories Co., Phila
Insulating Products Corp., N. Y.

BOILERS
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Combustion Engrg. Corp., New York, N. Y.
Connelly Boiler Co., The D., Cleveland, O.
Erie City Iron Works, Erie.
Heine Boiler Co., St. Louis, Mo.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Ladd Water Tube Boiler Co., Pittsburgh, Pa.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Vogt Mach. Co., Henry, Louisville, Ky.
Wickes Boiler Co., Saginaw.

BOILERS, HEATING
Edge Moor Iron Co., Edge Moor, Del.

BOILERS, WASTE HEAT
Edge Moor Iron Co., Edge Moor, Del.

BOILERS, WATER TUBE
Edge Moor Iron Co., Edge Moor.

BOOKS & SCHOOLS.
McGraw-Hill Book Co., N. Y.

BRICKS, FURNACE LINING
Norton Co., Worcester, Mass.

BREECHINGS
Connery & Co., Inc., Phila.
Heine Boiler Co., St. Louis, Mo.
Littleford Bros., Cincinnati
Prat-Daniel Corp., New York.

BRUSHES, DYNAMO AND MOTOR
Dixon Crucible Co., Jos., Jersey City, N. J.
LeValley Vitae Carbon Brush Co., New York, N. Y.

BRUSHES, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS
Brady Conveyors Corp., Chicago.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, COAL HANDLING
Jeffrey Mfg. Co., Columbus, O.

CAR DUMPERS
Wellman-Seaver-Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET
Jeffrey Mfg. Co., Columbus, O.
Webster Mfg. Co., The, Chicago

CASTINGS
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa
Girtanner Engrg. Corp., N. Y.
Hills-McCanna Co., Chicago.
Neemes Fdry., Inc., Troy, N. Y

CEMENT, FURNACE
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh.
Insulating Products Corp., N. Y.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., Inc., N. Y.

CEMENT GUNS.
Cement Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE
Botfield Refractories Co., Phila
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Johns-Manville Corp., New York
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., N. Y.

CEMENT, INSULATING
Insulating Products Corp., N. Y.

CEMENT, IRON
Smooth-On Mfg. Co., Jersey City

CHAIN WHEELS
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE
Link-Belt Company, Chicago.

CHEMICALS, WATER TREATING.
Chicago Chemical Co., Chicago
Permutit Co., New York.

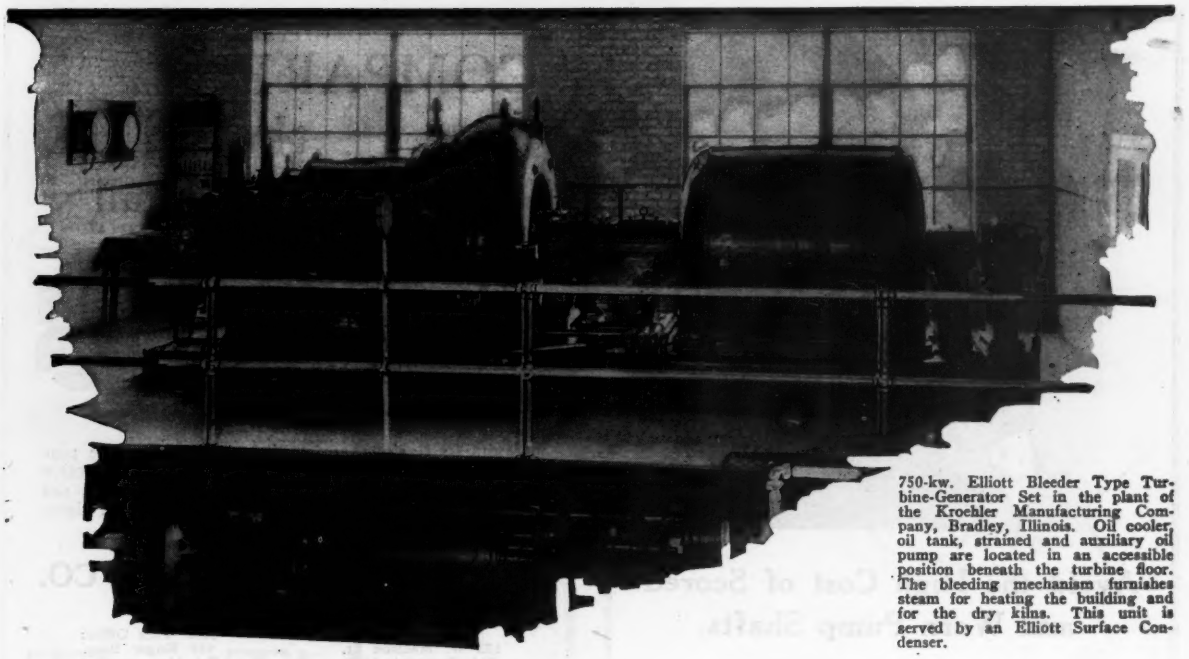
CHIMNEYS
American Chimney Corp., N. Y.
Prat-Daniel Corp., New York.
Rust Engrg. Co., Pittsburgh.
Springfield Boiler Co., Springfield, Ill.

CIRCUIT BREAKERS
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo
Roto Co., The, Newark, N. J.

CLEANING COMPOUND
Dearborn Chem. Co., Chicago.

COAL AND ASH-HANDLING MACHINERY
Allen-Sherman-Hoff Co., Phila
Brady Conveyors Corp., Chicago
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co Frederick, Md.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago



750-kw. Elliott Bleeder Type Turbine-Generator Set in the plant of the Kroehler Manufacturing Company, Bradley, Illinois. Oil cooler, oil tank, strained and auxiliary oil pump are located in an accessible position beneath the turbine floor. The bleeding mechanism furnishes steam for heating the building and for the dry kilns. This unit is served by an Elliott Surface Condenser.

from turbine inlet to condensate

The Kroehler Manufacturing Company chose not only undivided responsibility but "Characteristically Elliott" performance over the complete power unit when they installed this 750-kw. Bleeder Type Turbine-Generator Unit served by an Elliott Surface Condenser.

In the course of the first year's operation, this unit has been put to the test of performing under certain operating difficulties, and has come through with flying colors.

ELLIOTT
Power Units

Turbine-Generators
Engine-Generators
Condensers

ELLIOTT COMPANY
PITTSBURGH, PA.
General Sales Offices **JEANNETTE, PA.**
District Offices in principal cities

Elliott Power Equipment includes engines and turbines, generators and electrical machinery, condensers, deaerators, centrifugal blowers, and accessory equipment.

H-511

Avoid the High Cost of Scored and Worn Pump Shafts

By Using

SQUARE
PALCO
PLAITED PACKING

which carries such an abundance of graphite grease lubricant that the bearing surface of the shaft on the packing is kept under constant lubrication—

NO FRICTION

It is the friction caused by a hard unlubricated packing working against a pump shaft that not only scores the shaft but wears the packing and slows up the speed of the pump.

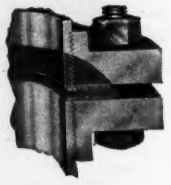
"Palco" has the lubricant that keeps the shaft under constant lubrication.

If you don't know the satisfactory service of "Palco" in centrifugal pumps let us send you without charge working samples to test under your own conditions. State size required.

Greene, Tweed & Co.
Sole Manufacturers
109 Duane St.
New York

COMPARE the TIME Required to Install "Flexitallic" with that of Other Gaskets

Reg. U. S. Pat. Off.



Flexitallic Gaskets are ready to drop into the pipe joint—inside the bolts. Then with quick, light action of a wrench they take up to a tight joint. Do not crush them. Very little pressure makes them tight. And they last and can be used over again.

"FLEXITALLIC" GASKET CO.
Camden, N. J.

Chicago Office:
123 W. Madison St.
Tel. Randolph 2100

New York Office:
539 Singer Bldg.
Tel. Hanover 0361

"Flexitallic" Gasket Co., Camden, N. J.
Without obligating me in any way, I will be glad to receive a copy of your "Four Reasons Why" circular.

Name..... Firm.....

Address..... .....

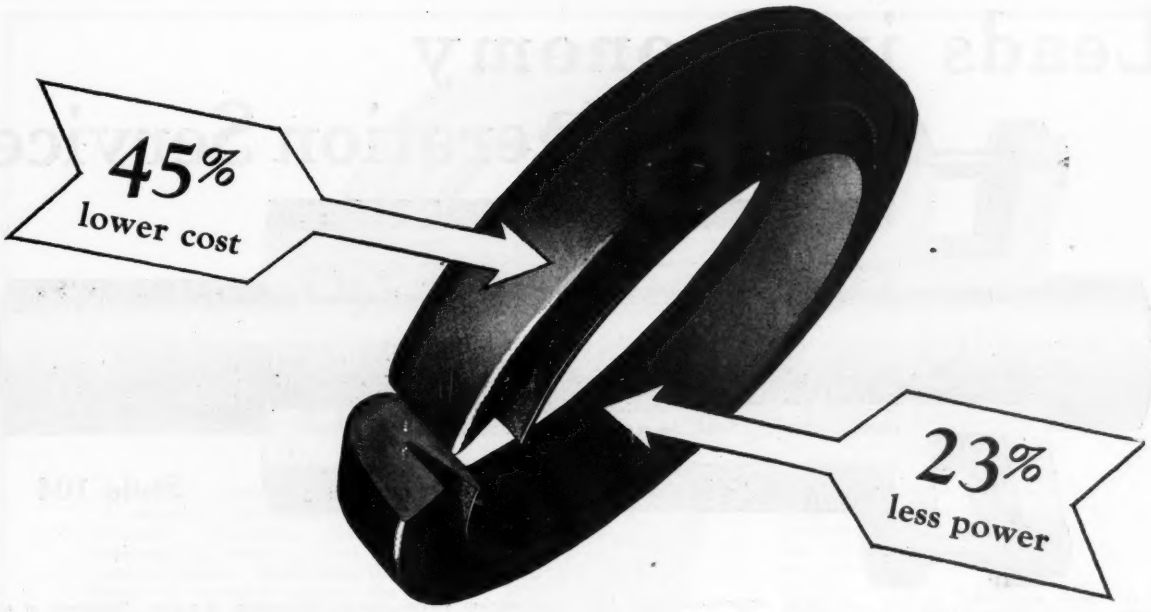
The Self-adjusting Packing *Daniel's P. P. P.*

Packing that relaxes its bearing as the steam pressure falls, cannot bind the rod.

P. P. P. automatically adjusts its bearing to suit the pressure in the cylinder. It therefore reduces frictional resistance to the lowest degree. There is no drag on the rod with P. P. P. in the stuffing box. Easy to apply and hard to wear out. Self-lubricating and steam-tight.

If your dealer cannot supply you promptly, write us.

QUAKER CITY RUBBER CO.
Main Offices and Factories
WISSINOMING, PHILADELPHIA
Branches: New York Chicago Pittsburgh San Francisco



The Tidewater Paper Company

made an important packing discovery

THEY had an electrically-driven triplex pump. It used up $20 worth of flax packing every 6 months—$40 a year.

They then changed to Sea Rings. A $115 set lasted 5 years, 2 months, 10 days—reducing the cost per year to $22.25.

But that was not all. When Sea Rings were installed the electric power consumed by the driving motor dropped from 9.6 kilowatts to 7.36 kilowatts—a saving in power cost of $167.73 yearly. Total Sea Ring saving per year therefore was $185.48.

Sea Rings will save money for you, too, perhaps not so much, perhaps more. A word from you brings complete details of the Tidewater test and further interesting facts about the structure of Sea Rings. Use the coupon to make your request.

JOHNS-MANVILLE
CORPORATION

JOHNS-MANVILLE CORPORATION
292 Madison Avenue, New York

Please send me full details of the Tidewater Paper Company test and data on Sea Ring packing. No obligation of course.

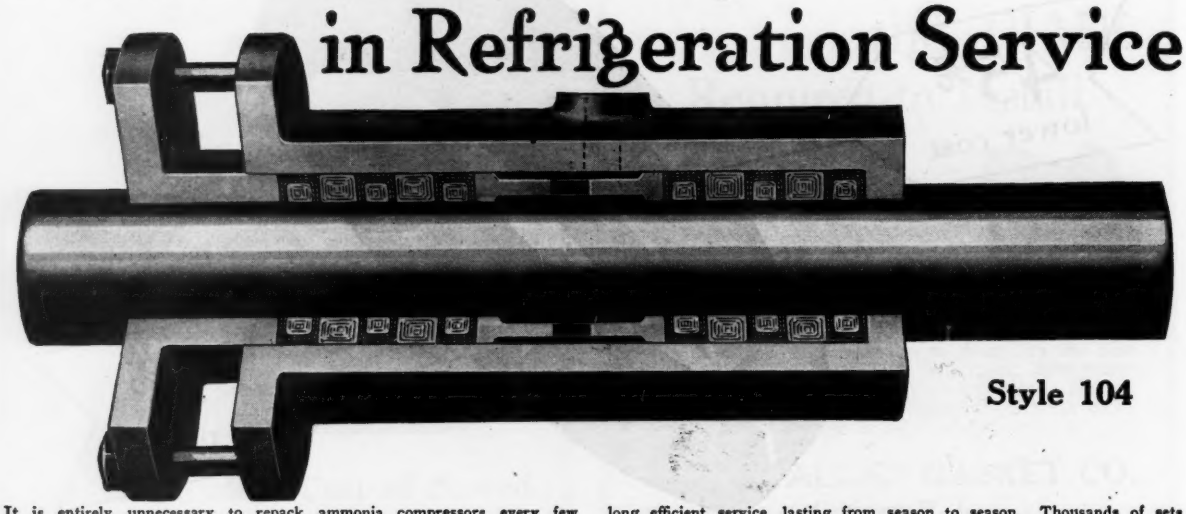
Name _____

Firm _____

Address _____

P.P.E. 12-15

Leads in Economy in Refrigeration Service



Style 104

It is entirely unnecessary to repack ammonia compressors every few months, to lose ammonia through leaky packing and to score your rods in trying to keep packing tight. The ideal ammonia packing is "John Crane" Metallic, Style 104. The babbitt foil presents a frictionless wearing surface. The channels in the alternate rings are resilient and wipe the ammonia film from the rod. The packing runs cool and gives long efficient service, lasting from season to season. Thousands of sets in use on every type of compressor. It is the most economical of all ammonia packings. Letters from many operators on request. In overhauling, order "John Crane" Style 104 direct from factory. Send us stuffing box measurements. Specify on all new equipment. Inquiries and consultation invited.

1802 Cuyler Avenue, Chicago **Crane Packing Company** 109 Broad Street, New York

"John Crane" Metallic Packing

Did You Get Your
1928 CALENDAR

The new, large wall size, clear type calendar for 1928 is now ready. Three months at a glance. A copy was made for you. If you haven't received it — send for it.

Crandall Packing Company, Palmyra, N. Y.
Gentlemen:
Pease send me my 1928 Crandall calendar.
Name .....
Company .....
Address .....

Good Will and Good Wishes

Occasionally—all too rarely—you read an advertisement that is like a hand clasp across space. Most sincerely we want this to be that kind—a genuine Old Fashioned—Merry Christmas, Happy New Year—and Peace (*) for you.

(*) *The New Year will be more peaceful if you use Crandall Value First Packings.*

CRANDALL PACKING CO., Palymra, N. Y.

O. J. Garlock, Pres. and Gen. Mgr.

No affiliation with any other concern selling the consumer.

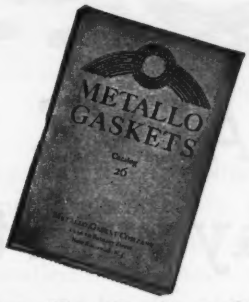
No. 2 METALLO

—when you review next year's expense, you will find it

THE GASKET THAT CUTS GASKET and FUEL COSTS

THESE corrugated-copper, asbestos-filled gaskets end expensive shutdowns due to blowouts and waste of fuel because of leaks. Made from the finest of 14-ounce copper, the Metallo Style 2 Gasket will not rust, rot, or deteriorate in service.

They can be used over and over when they are graphited. Try Metallo where the temperatures are highest and the conditions most severe.



Let us send you the Metallo Book which gives complete information on our entire line—a line which has been built by its successful service to plants. Metallo are the ideal gaskets and Discs to withstand excessive temperatures and high pressures.

Test Metallo Gaskets and Valve Discs by our free 90-day trial. You'll find them leaders in any service. Write for the 32-page book today.

Metallo Gasket Co.
New Brunswick, N. J.

Conneaut Plastic Metallic Packing

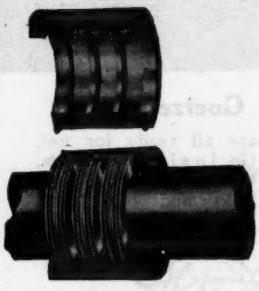
5-lb. and 10-lb. Cans at $1.50 Per Pound

Eliminates the size proposition.

Covers an extremely wide field of application, gives dependable service and lasts for years.

It is exceptionally suited for use on piston rods, valve stems, rotary pumps handling water, oil or chemicals.

Manufactured by
The Conneaut Packing Co.
353 Broad St., Conneaut, Ohio



31 Years' Experience

back of Holmes Packings and 23 patents assure you service not obtainable elsewhere. Orginators of Split Case.

for Steam, Air and Gas Split Case, etc.

HOLMES METALLIC PACKING CO.
70 Westminster St. Wilkes-Barre, Pa.

METALASTIC

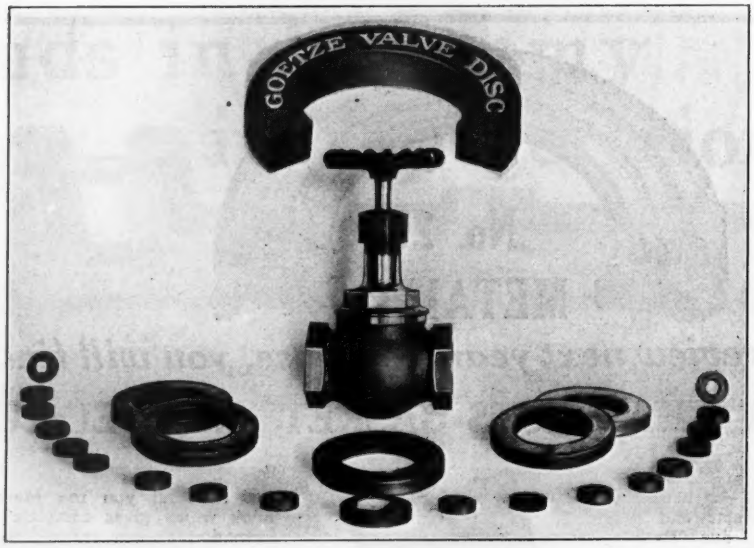
For All Stuffing Box Requirements

A DOZEN GOOD REASONS

METALASTIC is the ideal packing for stuffing-boxes.
METALASTIC is not a formed ring packing, hence,
METALASTIC does not require cutting or fitting, since
METALASTIC is furnished in one form for all equipment.
METALASTIC will neither bind nor wear nor score because
METALASTIC is composed of anti-friction materials.
METALASTIC will not harden after prolonged use, therefore
METALASTIC does not require replacement at any time thus
METALASTIC will eliminate shutdowns for maintenance repair.
METALASTIC is not an experiment under any operating usage for
METALASTIC has served well for more than seven years.
METALASTIC will save your money, your time and your patience.

Let us send you a working sample in proof of these statements.

METALASTIC INCORPORATED
JERSEY CITY, N. J.



GOETZE VALVE DISCS do away with this →

Costly labor, and shutdowns caused by frequent renewal of composition discs.

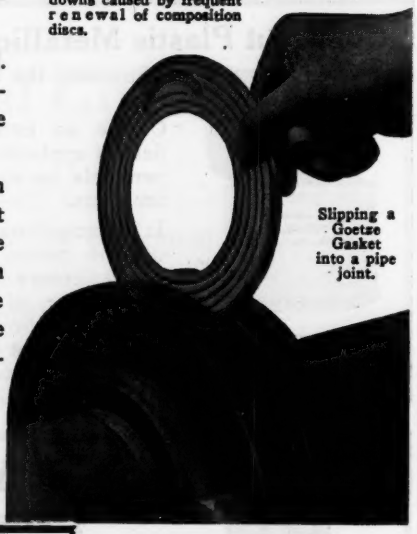
NIGHTS, Sundays and workdays, how the time and overtime counts up, the care and labor, the shutdowns, too, when ordinary valve discs must be renewed over and over again. And how easy it is to avoid all this with Goetze Copper-Jacketed Valve Discs!

Hundreds of plants have standardized on Goetze Discs because they prove in service that they last many times the life of ordinary composition discs.

Compressed asbestos in the center insures unlimited "give and take" for many seatings and the metal jacket, completely encasing the filler, protects it against deterioration.

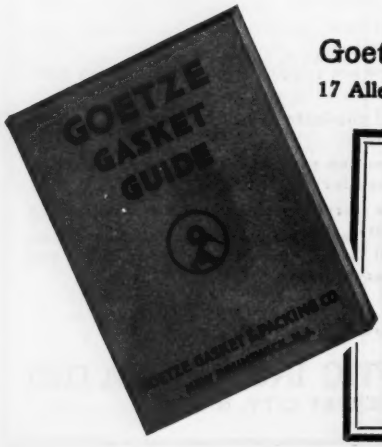
Monel metal jackets as desired. Highest pressures and temperatures cannot affect Goetze Valve Discs.

Keep valves tight; save steam and other media; put your plant on an economical basis and save yourself trouble! The coupon brings the book and our Free Trial offer on both Goetze Valve Discs and Copper-Asbestos Gaskets.



Slipping a Goetze Gasket into a pipe joint.

Goetze Gasket & Packing Co.
17 Allen Ave., New Brunswick, N. J.



Free Book—Free Trial

Goetze Gasket & Packing Co.,
17 Allen Ave., New Brunswick, N. J.

Please send Free copy of your 42-page book on Gaskets, Valve Discs and Packing with 90-day Free Trial Offer.

Name.....

Street.....

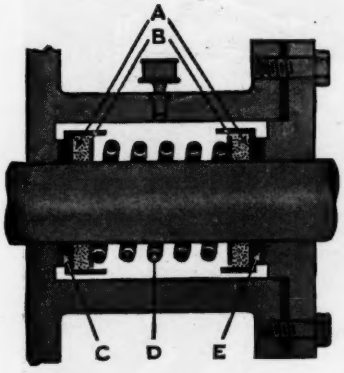
City.....State.....

Goetze Gaskets

are all ready for use. Go inside the bolts. Positive seal against leaks and blow-outs. Elastic; tight; durable.

RIGHT NOW, when the whole year is in review, consider the

Cooke *Seal Ring*



Cooke Seal Ring Assembly No. 3

Double Seal for rotary and centrifugal pumps on liquids having no lubricating value, consists of:

A—Rubber packing ring;
B—Metal plates;
C—Seal Ring;
D—Spring;
E—Seal ring.

The specially heat-treated seal rings, which have a low coefficient of friction, are kept compressed against the wall of the housing by the spring. The rubber packing rings grip both the shaft and the metal plates, so that the entire assembly rotates with the shaft, making the ground joint with stuffing box gland—the stuffing box becomes an oil reservoir.

Rotates with the shaft

The strictly mechanical device, which will save five times its cost every year, brings economy and ends leaks and packing troubles for plants wherever it is installed. All machines with rotating shafts can be improved by the addition of a Cooke Assembly which "rotates with the shaft" and eliminates hot boxes and shutdowns.

Saving 90 per cent of the friction and preventing scored shafts, the Cooke Seal Ring solves the stuffing box problem for once and all.

During the last summer more than 2,000 of these rings were sold a week. Such an enviable record is something to think about—especially when the users are continually recommending the Cooke products and are re-ordering them for other equipment.

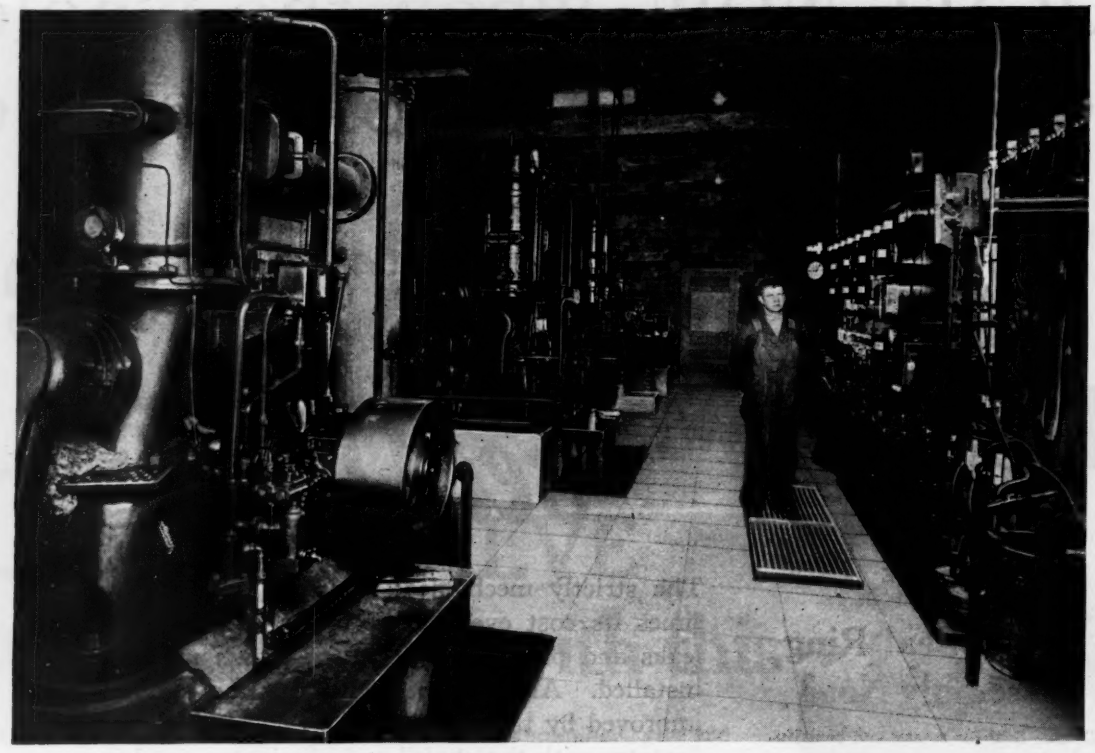
The great savings in proportion to the cost of the rings should interest you in your campaign against waste for 1928. Investigate these savings for yourself. Write for full information.

COOKE SEAL RING
28 N. Green St., Chicago, Illinois

Personally Guaranteed by

Geo Cooke
Inventor

This specially heat treated Cooke Seal Ring which ends stuffing box troubles is not a packing. It is easy to install and indestructible.



"I'm Strong for Nonpareil Diesel Oil"

Read what J. L. Prier, Superintendent of Light and Water Hugoton, Kansas, Has to Say:

"A few years ago we began using Nonpareil Diesel Oil in our three Fairbanks-Morse engines.

"No longer is it necessary to tear down our engines and clean out the carbon after short periods of operation. This, we were forced to do with other oils we have used.

"Recently, we inspected one of our Type Y, 50 H. P. engines and found very little carbon after a twelve months' run. Our large engine, a new Type Y, 120 H. P., was started on Nonpareil Diesel Oil in May, 1925. It has carried a full load twelve hours per day and as yet we have not pulled a piston, taken up a rod bearing or cleaned the carbon out of the exhaust system.

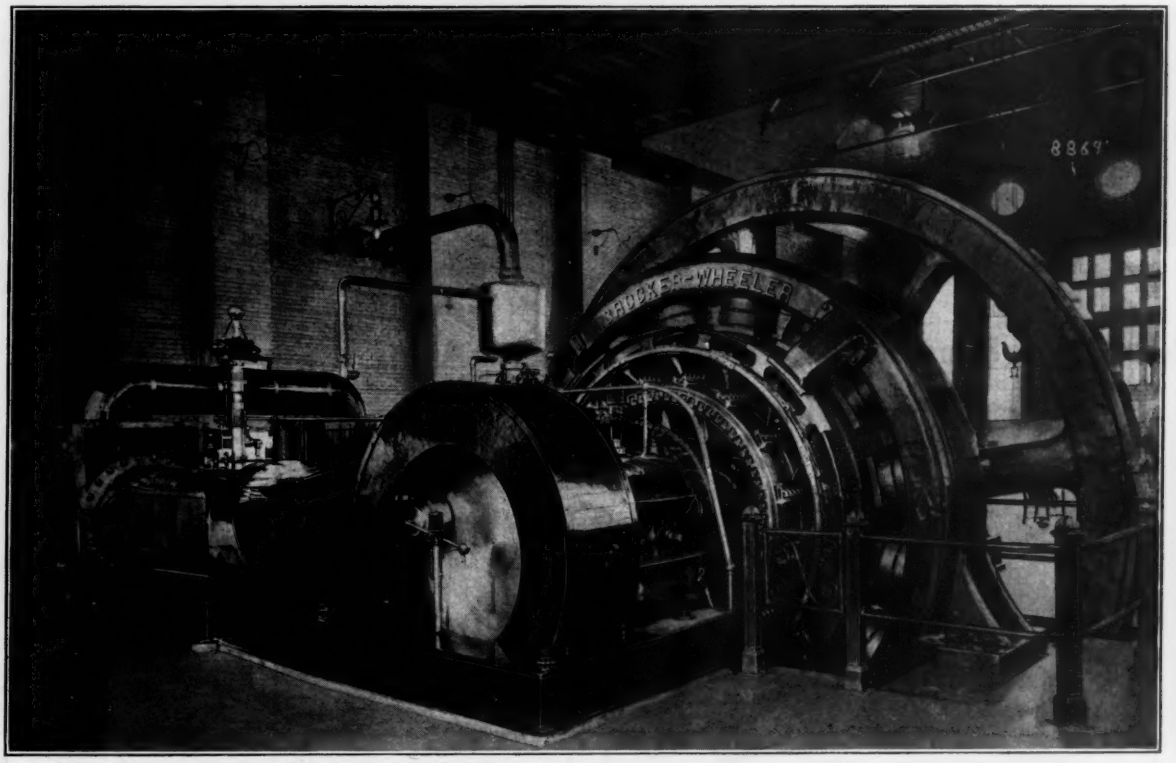
"So great is our satisfaction with Nonpareil Diesel Oil that we are afraid when the time does come to tear down our enignes, we will have forgotten how to begin."

To assist operators of Diesel Engines in obtaining the correct grades of lubricants, we offer the services of our Lubrication Engineers. These men are qualified to recommend the proper grades of oil for your use. To avail yourself of this service does not obligate you in any way.

Just phone or write our nearest branch office

STANDARD OIL COMPANY
(INDIANA)

General Offices: 930 S. Michigan Avenue CHICAGO, ILLINOIS



SCIENTIFIC LUBRICATION

Engine Bearings That Have Not Seen Light For 24 Years

This Allis-Chalmers engine, cross compound 1900 type was erected in the Spring of 1903 by Charles MacDonald at the plant of Pettibone Mulliken Company, Chicago. It is 24" and 40" by 48", running 85 rpm. and operates a 600 kilowatt Crocker-Wheeler generator.

In October, 1903, the unit was put in service. It has been running constantly since that time in accordance with ordinary factory practice.

The crank pins have never been opened even for inspection, and are running cool and quiet today.

The bottom of the main bearings have never seen light since the engine first started, and they have not worn down enough to require any lowering of the generator frame. Checking still shows it central.

Cylinders have never been bored and do not show a scratch. In this same room are four other cross compound units that have been running for 20 years, of which the same report is true.

The engineer is Mr. Willard Starr, now Superintendent of Power of one of Chicago's large manufacturing industries. The first oils he ever used on this engine were Dearborn Ft. Douglas XX Special Cylinder Oil and Ft. Clyde Engine Oil. It is the oil he uses today. There has never been a drop of any other kind of oil used there in 24 years.

Some will call this good luck, but when the country is dotted with similar cases and when the world's record turbine run was made on our unchanged Ft. Curtis Turbine Oil it looks like good luck in lubrication is closely associated with Dearborn oils.

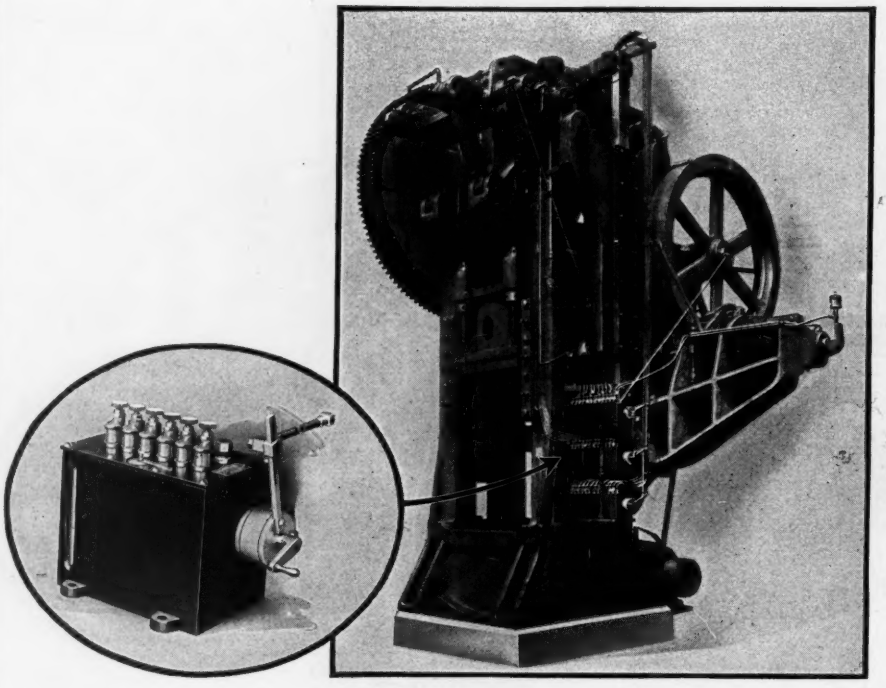
Send for our textbook, "Lubrication from Tallow to Dearborn Oil." It describes the lubrication requirements of all modern services. Gives standard tests of lubricating oils, fully illustrated; has color charts, and tells you how to select lubricants properly.

DEARBORN CHEMICAL COMPANY

310 S. MICHIGAN AVE., CHICAGO Canadian Factory and Offices, 2454-2464 Dundas St., West, Toronto 299 BROADWAY, NEW YORK

Dearborn

REG. U.S. PAT. OFFICE



BOWSER ESTABLISHED 1885

We will be at the Chicago Power Show, February 14 to 18, in Booth 164

How stamping presses oil themselves–automatically

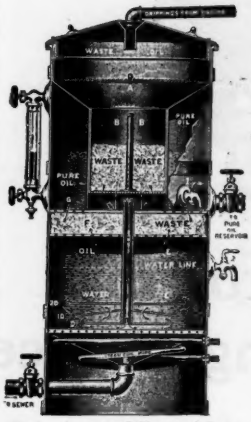
It used to take a man, a ladder and 72 minutes to oil these presses—and the job had to be done twice a day. Now each press oils itself from a centrally-located, easily-accessible oiler—a BOWSER Model "T" Force-feed Lubricator does the job automatically.

No more shutdowns for emergency oilings. No more accidents to the oiler. No more oil wasted or spilled. And, best of all, *every* bearing is adequately oiled *all* the time!

Our Model "T" Lubricator is ratchet or belt driven—assuring uniform dependability of lubrication. Bowser construction throughout—nothing better is or can be made. For definite application, blue prints, pictures, etc., please address Dept. 74

S. F. BOWSER & COMPANY, Inc.
LUBRICATION ENGINEERS AND MANUFACTURERS
FORT WAYNE, INDIANA, U.S.A.

Reduce Operation Costs with a BURT *Cross* Oil Filter



Style A, especially useful for filtering systems.

Oil used in lubricating machinery passes through the bearings, drips away, and is wasted unless you let a Burt Oil Filter reclaim it. Pays you large dividends and requires practically no attention or upkeep and enables you to use your oil over and over again.

30 Days' Trial

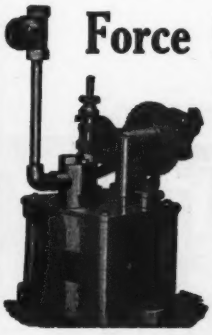
Burt offers to send any oil filter to any responsible house on 30 days' trial. If it is found upon trial that it does not reduce lubricating bills by at least 60 per cent it may be returned and Burt will pay the charges both ways. There are Burt filters for every service.

THE BURT MFG. CO.

44 E. South St.
Akron, Ohio, U. S. A.

The Canadian Fairbanks-Morse Co., Ltd., Montreal, Sole Representatives for Burt Oil Filters and Exhaust Heads for Canada.
George W. Reed & Co. Ltd., Montreal, Sole Manufacturers of Burt Ventilators for Canada.

Force Feed Lubricators



Hills-McCanna Lubricators are used in many of the world's largest power plants. They deliver oil to all bearings on engines, compressors, centrifugal pumps, in fact to any equipment where friction is a hazard. A type for every lubricating need—from 1 to 60 feeds.

Steam Specialties

Air cocks, high pressure gauge cocks, low water alarms, fusible plugs, and many other specialties comprise the Hills-McCanna Line. Our Catalog describes them in detail.

Boiler Feed Pumps

—for handling liquid compounds, for water softening and for the treatment of boiler water to prevent scale and foaming.

Write for our Power Plant Equipment Catalog

HILLS-McCANNA CO.
2349-59 Nelson Street
CHICAGO

GARLOCK

COMPLETE PACKING INFORMATION

An MA-1925 catalog, describing Garlock Mechanical Packing Service, should be in the hands of every person having supervision over any type of mechanical equipment.

Write Us and Obtain a Copy

THE GARLOCK PACKING COMPANY
50 MAIN STREET
PALMYRA, N.Y.

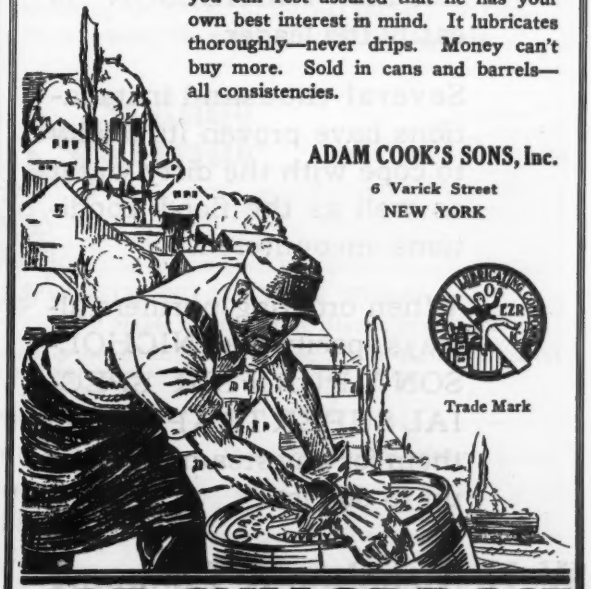
The Standard Packing of the World

The Keystone Lubricating Co.
Executive Office and Works: Philadelphia, Pa.

TRUST YOUR DEALER

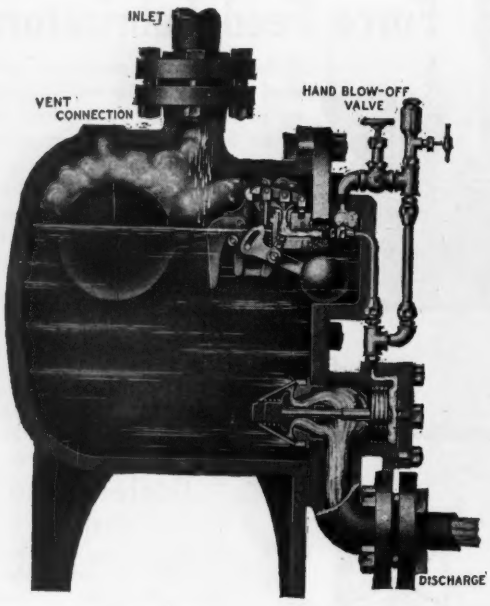
If your dealer gives you Albany Grease you can rest assured that he has your own best interest in mind. It lubricates thoroughly—never drips. Money can't buy more. Sold in cans and barrels—all consistencies.

ADAM COOK'S SONS, Inc.
6 Varick Street
NEW YORK



Trade Mark

ALBANY GREASE



Draining Steam Purifiers

Not many types of traps can handle the discharge from purifiers, but of the few that can the "NICHOLSON" is easily the leader.

Several thousand installations have proven its ability to cope with the dirty water as well as the flood conditions encountered.

When ordering purifiers always specify the "NICHOLSON" PURIFIER SPECIAL SUPER TRAP to drain them for any steam pressure up to 600 lbs.

W. H. Nicholson & Company
120 Oregon St., Wilkes-Barre, Penna.

Latest Bundy Three-valve Trap

Call! call for this fuel saving service

Bundy service starts with the first inquiry and continues all the way through the purchasing and satisfactory operation of these traps.

First, great care is taken in assisting in the selection of the right type and size of traps for the particular conditions under which they are to serve. Often large savings are effected in first cost because of the large capacity of Bundy Traps.

Most suitable location for best results is part of this service and it continues, whenever necessary, to insure the complete satisfaction and large fuel savings that are obtained in other plants with Bundy Traps.

Service is conducted by a highly experienced staff without any extra charge. Write now for information and the latest Bundy Book.

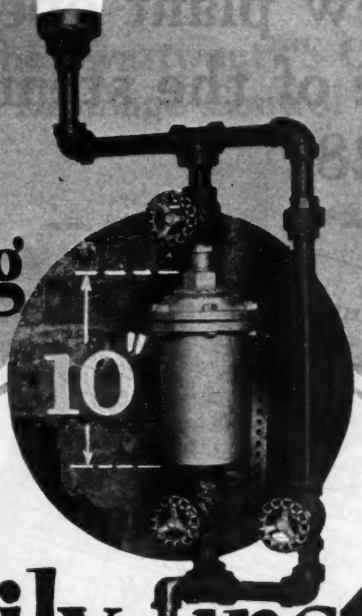
Bundy Steam Trap Co.
39 Elm St., Nashua, N. H.

Engineering representatives in the principal power centers.

This 45-page Bundy Book tells about the full line of products. Write for free copy.

BUNDY Steam Traps *for every service*

The Armstrong Trap



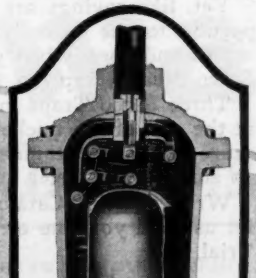
is easily installed

FEW fittings are needed with the Armstrong steam trap. The inlet is at the bottom and the outlet at the top, making the connection a simple matter.

The Armstrong occupies small space and is light in weight so that no support for the trap is needed. The No. 2 trap—½ in. or ¾ in. connections—is only 10 in. high and 6¼ in. in diameter. Yet it will handle 2065 pounds of water per hour at 80 pounds pressure.

Because of its simplicity and compactness, the Armstrong Trap requires little time for installation, an item which in itself effects a material saving.

The inverted bucket combined with the compound levers [a patented feature] is the reason for the small size and large capacity of the Armstrong Trap. Water, filling the bucket, causes it to sink and the attached levers produce a force which opens a large valve. Steam entering the inverted bucket causes it to rise, thus closing the valve quickly and tightly.



Sectional view of the Armstrong Trap

90 days trial

TRY out an Armstrong Trap for 90 days. Then send it back if you wish. No obligation.

ARMSTRONG MACHINE WORKS,
310 Maple Street, Three Rivers, Michigan.

Please ship prepaid an Armstrong Trap for a 90-day test. When the test is completed the trap will be returned collect.

For service on .....

Size of pipe ..... *Steam Pressure (Maximum)* .....

Name .....

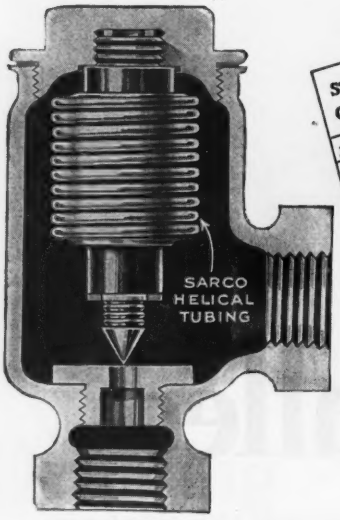
Position .....

Firm .....

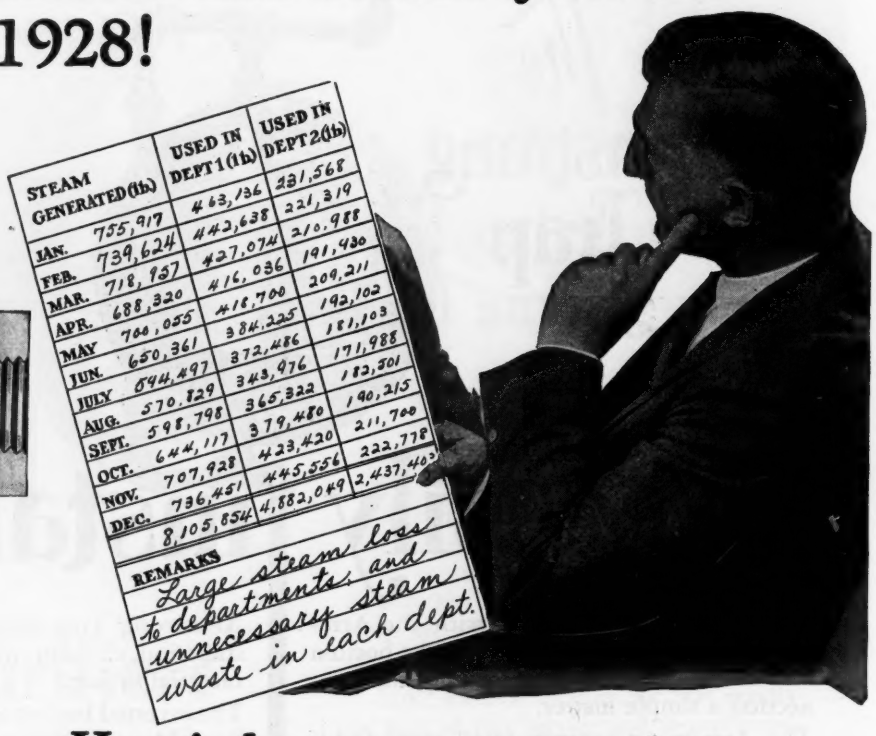
Street Address .....

☐ *Send Catalog Only* PPE 12-15 Gray

As you review plant operation for 1927, *think* of the steam you can save in 1928!



SARCO Steam Trap Number 9



Here's how—accept our 30-day free trial offer NOW!

Thousands of dollars' worth of expensively generated steam is being saved every month in the year by Sarco Steam Traps.

See our advertising for the statements of the exact sums saved in many plants which have given us the facts voluntarily, or write us for copies of the original letters, in our files.

How would you like to save $1,680 in a single month, as in one plant, or an average of $5,100 as in another, or approximately $7,500 a month as in still another plant?

Yet, like savings are yours, in proportion to the steam your plant generates and uses, when you equip with Sarco Steam Trap No. 9.

Three Sarco Traps may be installed at the cost of one bucket trap; they require little space, cannot freeze and are so simple they never get out of order.

Write now for Catalogue B-286 and let us send you one on 30 Days' Free Trial.

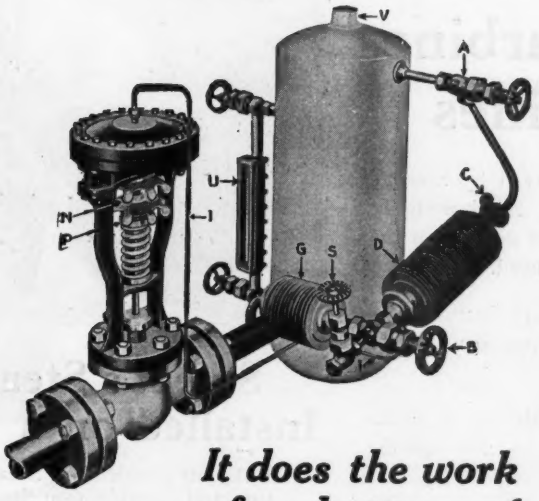
Two Other SARCO Steam Savers

SARCO CO., Inc., 183 Madison Ave., New York

Boston, Buffalo, Chicago, Cleveland, Detroit, Los Angeles, Philadelphia, St. Louis, San Francisco, Peacock Bros., Ltd., Montreal

"What SARCO saves in other plants it can save in your plant!"

The Swartwout "S-C" Drainage Control



It does the work of a battery of steam traps

PIPE all return condensate to the Swartwout "S-C" Drainage Control instead of putting a battery of traps on the job. This self-contained unit has a larger capacity than any trap of the same size and works perfectly on mixtures of steam, air and water. It will not air bind and will discharge continuously and in the same proportion to condensate flow. Let us send Bulletin 600-B which fully describes this equipment.

Swartwout

Controls and S-C Regulators

THE SWARTWOUT COMPANY, 18541 Euclid Avenue, CLEVELAND
Please send complete information on the following:

Swartwout	☐ SEPARATORS, AIR, STEAM AND OIL ☐ TRAPS, HIGH AND LOW PRESSURE	☐ CAST IRON EXHAUST HEADS ☐ FEED WATER HEATERS
S-C	☐ FEED WATER REGULATORS ☐ PUMP GOVERNORS	☐ DRAINAGE CONTROL SYSTEMS ☐ DIFFERENTIAL PRESSURE VALVES

*Name*_____ *Address*_____

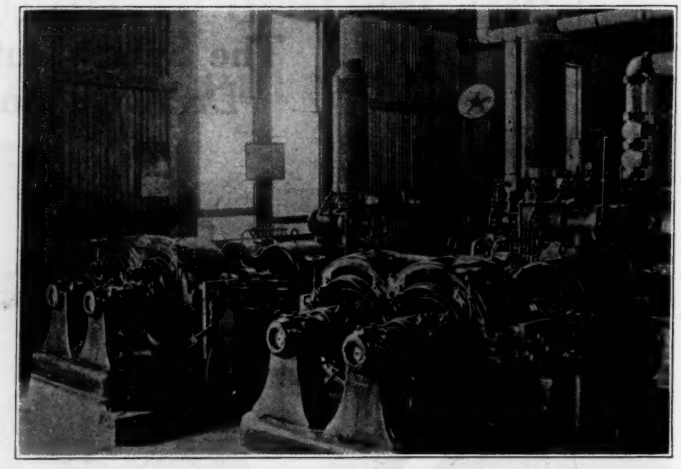
Reduce Operating Cost and Insure Safety of Turbines and Engines

Repairs, oil and fuel are saved by Sweet's Oil and Water Separators. So thoroughly do they operate that you can depend on the utmost economy wherever used.

More than 12,000 satisfactory installations should warrant your investigation of Sweet's Separators.

Our modern facilities enable us to make them in all sizes suitable for any specific condition.

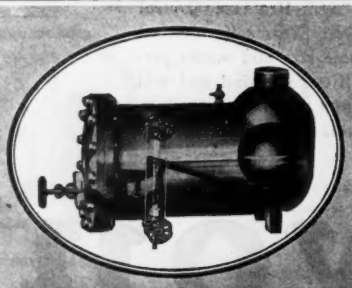
Write for catalogue giving full information.



Sweet's Steam Separator Installed on a Steam Turbine

Put your problems of Steam Separation, Oil Separation and Combination Steam and Oil Separation up to our 25 years' experience.

THE DIRECT SEPARATOR CO., Inc., 218 So. Geddes St. SYRACUSE, N. Y.



THE two cone valves of the Davis Steam Trap adjust themselves automatically for any rate of flow required, and are balanced, so that this trap works equally well under any pressure. Since the valves are balanced, one adjustment serves for the life of the valves; once set, they will remain accurate and tight closing until worn to the point of replacement.

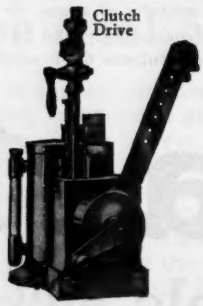
Particularly useful for installations where a large reserve capacity is required in draining condensate. This Davis Trap stands up under the most difficult service conditions with typical Davis performance.

Send for the Davis catalogue and get the full description. Compare the ratings and the cost and you will see the advantages of Davis Traps.

G. M. DAVIS REGULATOR CO.
422 Milwaukee Avenue Chicago, Illinois

DAVIS VALVE SPECIALTIES
STEAM-SAVERS SINCE 1875
VALVE MAKERS FOR OVER FIFTY YEARS

ROCHESTER LUBRICATORS



for Oil Economy

on engines, compressors, pumps, etc. They are all equipped with the Multiplus Sight Feed which is a combination three way cock and Sight Feed Device and which shows every drop of oil fed.

Write for Catalogue "T" and 30-day free trial of any Rochester Lubricator.

GREENE, TWEED & CO.
109 Duane Street, New York
Sole Manufacturers. Factory, Newark, N. J.
Canadian Agents: Darling Brothers, Ltd., 120 Prince St., Montreal
English Agents: Jenkins Bros., Ltd., 6 Great Queen St., Kingsway, London, W. C. 2.

100% Lubrication
From Every Gallon of Oil

Let us prove to you that a "Manzel" Oil Pump makes every drop of oil work and saves 30 to 60 per cent of oil cost. You may try a "Manzel" thirty days free.

Write for catalog

Manzel Brothers Co.
327 Babcock St.,
Buffalo, N. Y.

The "Manzel" Oil Pumps

All Over the World Type "S" Oil Separator

In Java, China, Peru, Brazil, England, Belgium, in fact all over the world, the *Wright-Austin Type "S" Oil Separator* is a great traveler, and in the United States there are thousands taking oil out of steam down to .3 grain per gallon, which is a mere laboratory trace. If oil is to be removed from steam or gas the type "S" can do it completely.

Send for Bulletin 703

Wright Austin C... roit

315 West Wood...

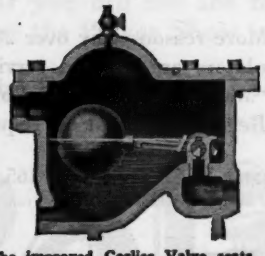
APEXIOR REG U.S. PAT OFF

—an accepted protective coating for hot water and steam surfaces of boiler plant equipment

Write for Bulletin

THE DAMPNEY COMPANY OF AMERICA
Hyde Park, Boston, Mass.

ACE STEAM TRAP
The trap with the Improved Corliss Valve



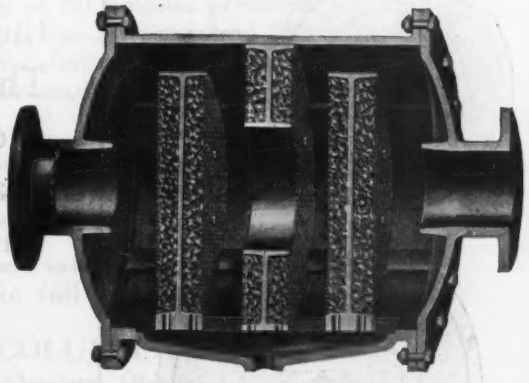
A High Quality Trap that sells at a moderate price

Consists of only six parts. The improved Corliss Valve seats steam-tight, gives large capacity, is self-cleaning and cannot clog or air bind. Automatically adapts itself to either continuous or intermittent discharge as the flow of condensate requires. Write for Bulletin.

The W. B. Connor Company, Inc.
367 Lexington Ave., New York

The EXHAUSTEAM Purifier and Drier

Patented

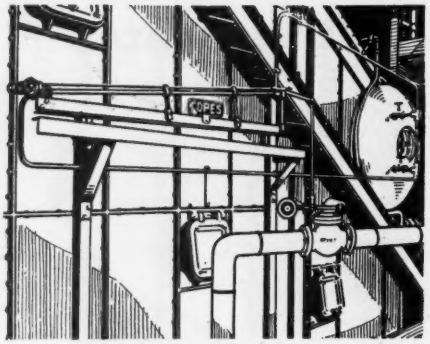


Results are sure

Renders dirty, wet exhaust steam positively clean and dry. The steam receives four distinct separating effects that remove the oil and oily impurities. No other method of steam purification can be more thorough or dependable. Write for bulletin.

Atlantic Engineering Company
19 Cortlandt St., New York

The COPES responds *instantly* to changes in water level—No lag



It takes *less than one second* for changes in boiler water level to effect the expansion or contraction of the thermostatic tube of the COPES Feed Water Regulator. With the stress of the levers in the same direction at all times, this change in water level causes an immediate change in the control valve opening.

Any lag in operation is impossible because of the powerful actuating force that is constantly available. There is no time loss due to inertia or lost motion in the moving parts.

The accompanying charts show that the COPES Regulator acts instantly. There is no lag. The COPES control valve is definitely geared to boiler water level —an exact valve opening for given furnace and load conditions.

These Charts show The COPES' instant response to changes in water level.

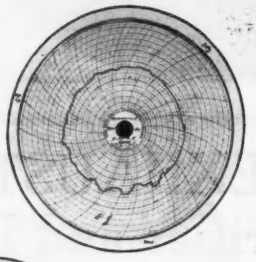


Chart No. 1 shows the movement of the COPES Regulator valve. The pen moved toward the center of the chart as the valve opened.

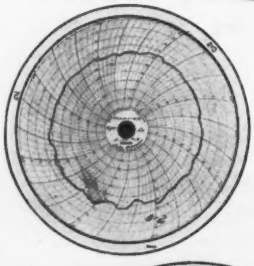


Chart No. 2 shows the movement of the water level with the pen moving toward the center of the chart as the water level lowered.

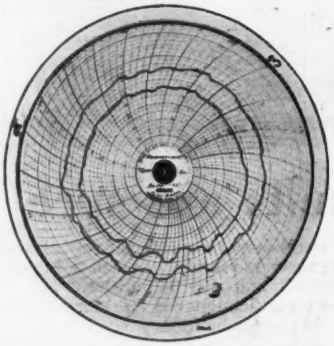


Chart No. 3 is a composite of No. 1 and No. 2—two exposures on the same plate. Note how the valve movement instantly follows the water level. This shows how accurately and how quickly the COPES Regulator responds to every change in furnace and load conditions.

More reasons why over 28,000 COPES Regulators are now in service are given in "Modern Methods of Boiler Feed Water Regulation," sent on request.

NORTHERN EQUIPMENT CO., 165 Grove Drive, Erie, Pa.
Branch Plants in Canada, England, France, Germany, Austria and Italy

Reliance Forged Steel Safety Water Column No. 750 photographed in the Reliance factory just before shipment to the Power Show. Column, floats, whistle valves, water gauge and gauge cocks all with a wide margin of safety over the guaranteed pressure of 750 pounds.

High Pressure Leadership

POUND by pound Reliance boiler protection goes up. Beginning at 50 pounds pressure nearly 50 years ago, it has now reached 750 pounds, in regular standard columns. And special Reliance columns have been made for still higher pressures.

This means thoroughly proved engineering design, materials and manufacture all the way up the scale of pressures. You can depend on Reliance.

If you did not see this latest safety water column at the Power Show, write for full details.

The RELIANCE GAUGE COLUMN COMPANY
5932 Carnegie Ave., Cleveland, Ohio

TRADE MARK REG. IN U.S. PAT. OFF.

Reliance

SAFETY WATER COLUMNS

The accuracy of Mason Regulators does not diminish with long continued use. They are designed, built and tested to work efficiently and with the least amount of attention.

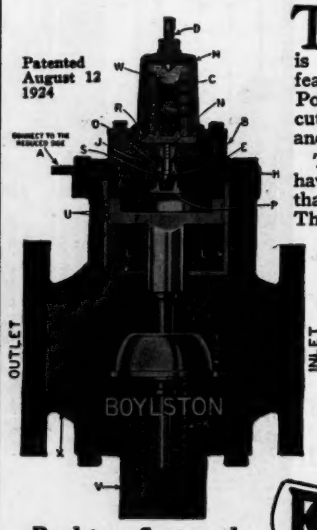
Mason Regulators for every service pressure are shown and described in Catalog No. 62—write for your copy.

Mason Regulators

MASON REGULATOR CO.
Boston, Mass.
San Francisco Office, 606 Howard Street

1366

You will *never* have to take *this* valve out of the pipeline to renew any working part



Boylston Seat and Disc Insure Perfect Tightness.

THE improved design of the main valve disc is one of the important features of this regulator. Positively prevents steam cutting of the main seat and disc.

The regulator will always have a perfect main seat, that will be steam-tight. This is especially important where the reduced side would have what is termed a "dead end," for it will prevent the pressure from building up.

Pilot Operated
Pressure Regulating Valve
Write for Catalogue

BOYLSTON
Steam Specialty Co.
118 W. Illinois St.
Chicago, Ill.

More H.P., less cost, with Hoppes Steam Specialties

Hoppes Regulating Valve, a factor in the automatic operation of Hoppes Heaters.

Engineers of plants large and small are enthusiastic supporters of Hoppes Steam Specialties — they are using them!

Because superfine construction together with exact, automatic operation free from repairs insures satisfaction wherever Hoppes Steam Specialties are used. Write for sizes and types of Heaters, Purifiers, V-Notch Meters, Separators, Exhaust Heads, etc.

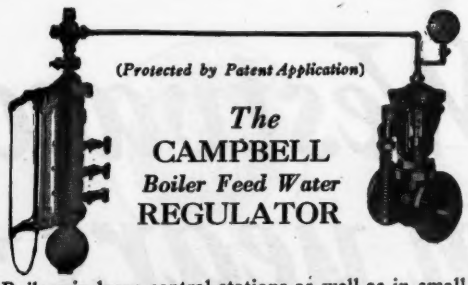
The Hoppes Manufacturing Co.
70 Larch St. Springfield, Ohio

HAGAN

Combustion Control
Steam Purifiers
Steam Separators
Boiler Water Conditioning
(for the prevention of scale and corrosion)

HAGAN CORPORATION
Combustion and Chemical Engineers
BOWMAN BUILDING, PITTSBURGH, PENN.

For Central Stations



(Protected by Patent Application)

The
CAMPBELL
Boiler Feed Water
REGULATOR

Boilers in large central stations as well as in small plants are invariably improved by this remarkable regulator.

The Campbell is proving its worth on boiler after boiler where other regulators have failed. If yours is one of those "difficult" boilers, it NEEDS a Campbell.

Exceedingly simple. Keeps the water level RIGHT WHERE YOU WANT IT all the time. No floats. No links. No thermostats. No thermal lag. No parts to go wrong. Performance absolutely guaranteed.

Complete information is yours on request.

Regulating Valves for Every Service

On Which Do You Want Information?

- ☐ Feed Water Regulators
- ☐ Reducing Valves
- ☐ Damper Regulators
- ☐ Temperature Regulators
- ☐ Pump Governors
- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves

Atlas Valve Co., 291 South St., Newark, N. J.

R-K
TRADE MARK REG. U.S. PAT. OFFICE

present the new line of

Solenoid Operated Valves and Servo Motors

They include: R-K Removable Cage Type Balanced Valve; R-K Solenoid Operated Valves arranged for Direct Current and Alternate Current Operation; R-K Servo Motors operated by Double Solenoids.

Exhibited for the first time at the New York Power Show, these new additions to the products of the long established R-K Line of Hydraulic Step-Action Regulators, Motor Operated Regulators, Uniseat Valves, Chronometer Valves and other Specialized Equipment, attracted wide and favorable attention.

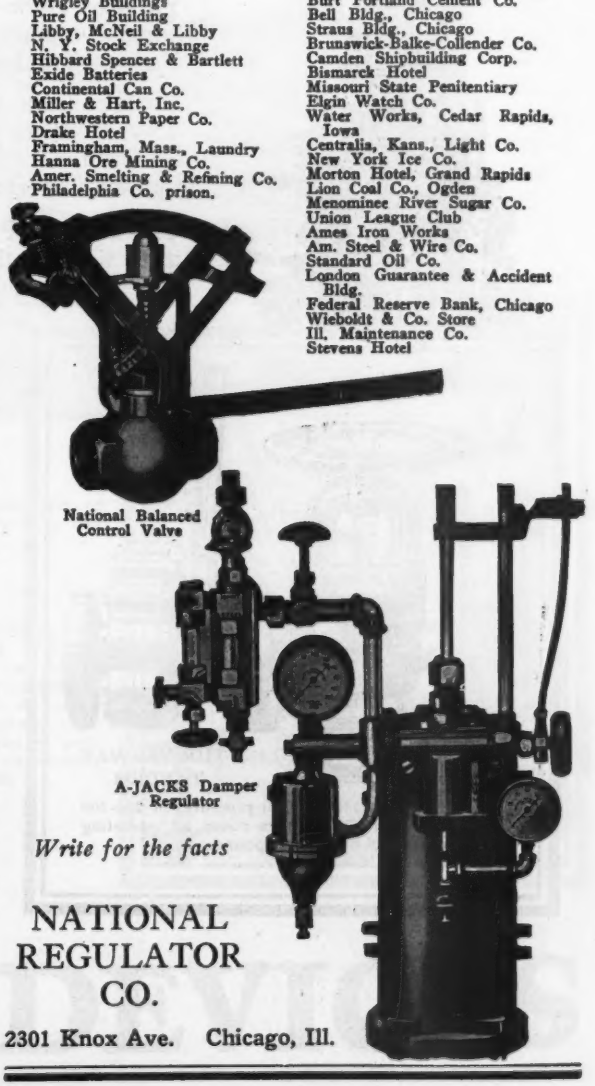
Write for full information.

R-K RUGGLES-KLINGEMANN MFG CO.
Manufacturers Complete Line Power Control Equipment
MAIN OFFICE and WORKS R-K Building, Salem, Mass
Boston Office, McClintock Bldg. New York Office, 50 Church St.

A Review of 1927 Finds A-JACKS Damper Regulators and NATIONAL Control Valves

serving in such plants as the following:

U. S. Steel Corp.
General Motors Co.
Campbell Soup Co.
Ill. Bell Telephone Co.
International Harvester Co.
Modart Corset Co.
Fontanelle Hotel, Omaha
Coco Cola Co.
Wrigley Buildings
Pure Oil Building
Libby, McNeil & Libby
N. Y. Stock Exchange
Hibbard Spencer & Bartlett
Exide Batteries
Continental Can Co.
Miller & Hart, Inc.
Northwestern Paper Co.
Drake Hotel
Framingham, Mass., Laundry
Hanna Ore Mining Co.
Amer. Smelting & Refining Co.
Philadelphia Co. prison.
Leiter Bldg.
Bemis Bag Co., Memphis
Marshall Field Bldg.
Bauer & Black Co.
Oliver Typewriter Co.
Standard Sanitary Mfg. Co.
Marquette Bldg., Chicago
Public Service Co., Tulsa, Okla.
Burt Portland Cement Co.
Bell Bldg., Chicago
Straus Bldg., Chicago
Brunswick-Balke-Collender Co.
Camden Shipbuilding Corp.
Bismarck Hotel
Missouri State Penitentiary
Elgin Watch Co.
Water Works, Cedar Rapids, Iowa
Centralia, Kans., Light Co.
New York Ice Co.
Morton Hotel, Grand Rapids
Lion Coal Co., Ogden
Menominee River Sugar Co.
Union League Club
Ames Iron Works
Am. Steel & Wire Co.
Standard Oil Co.
London Guarantee & Accident Bldg.
Federal Reserve Bank, Chicago
Wieboldt & Co. Store
Ill. Maintenance Co.
Stevens Hotel



National Balanced Control Valve

A-JACKS Damper Regulator

Write for the facts

NATIONAL REGULATOR CO.

2301 Knox Ave. Chicago, Ill.

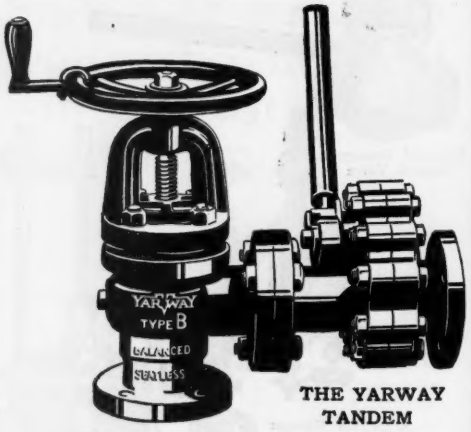
Yarway has served Westvaco sixteen years

THE West Virginia Pulp and Paper Company manufactures thirty-eight varieties of Westvaco Mill Brand Papers, and has eight mills in Virginia, West Virginia, Pennsylvania, New York and Maryland, with a daily capacity of 1200 tons.

Yarway Blow-Off Valves have been used by this prominent paper company since 1911. The latest order was for twelve sets of Yarway Tandems for the blow-off lines of the Covington, Va., Mill.

Each boiler in the Covington Mill is also equipped with the Yarway Floatless Hi-Lo Alarm Water Column and the Yarway-Sesure Inclined Water Gage, thus centering the responsibility for two important boiler devices.

The Yarway Floatless Hi-Lo Alarm Water Column depends for its action on the displacement of solid weights, high and low boiler water levels disturbing their equilibrium and operating a whistle alarm or a light signal through a Mercoid switch. The column body and flanges are forged from solid steel.



THE YARWAY TANDEM

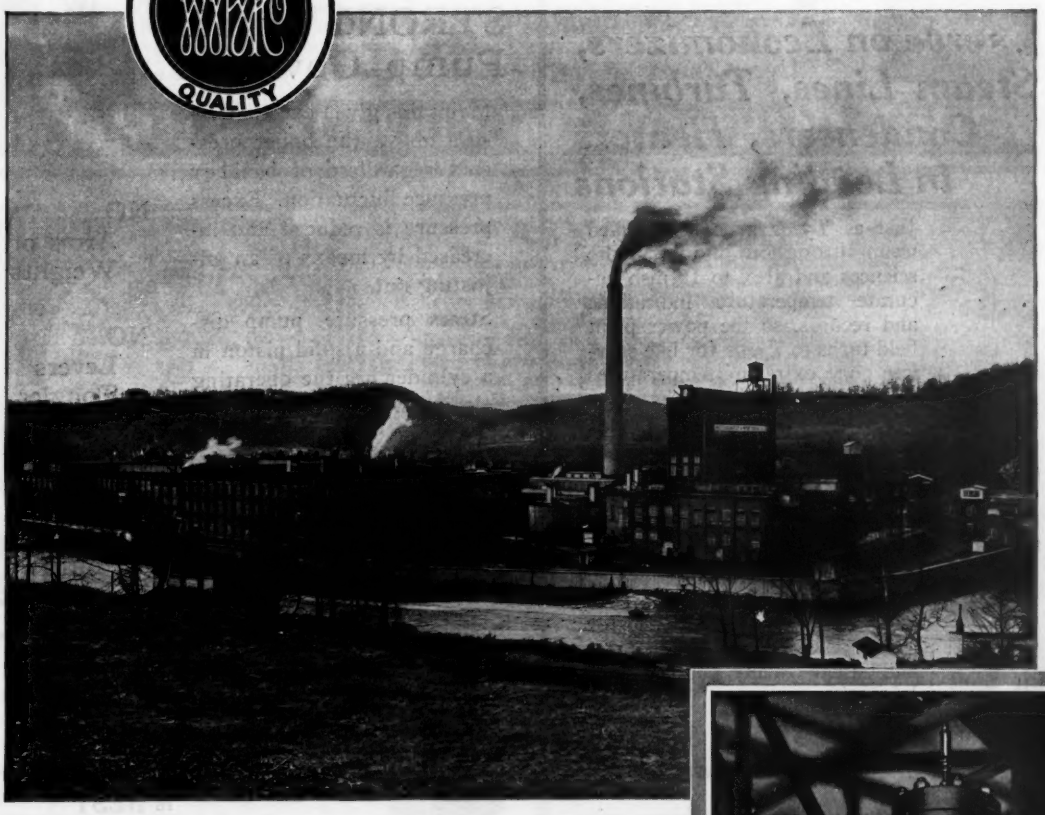
(Fig. No. 3486-58) for pressures of 200-300 pounds. Other types cover all operating pressures up to 1350 pounds.

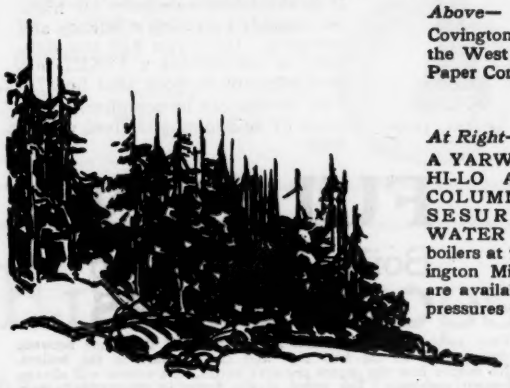
The Yarway-Sesure Inclined Water Gage is furnished with all types of the Water Column. Its design provides for instant reading, however high it may be placed above the fire-room floor. It is also sold as a separate unit for use on existing water columns or to supplant the usual vertical water gage.

Yarway Seatless and Double Tightening Blow-Off Valves for all pressures are illustrated and fully described in Booklet B-410-C, and Yarway Floatless Hi-Lo Alarm Water Columns and Yarway-Sesure Inclined Water Gages for all pressures in Bulletin WC-1801. We will be pleased to send you either or both. Write us today.

YARNALL-WARING COMPANY
Mermaid Street Philadelphia

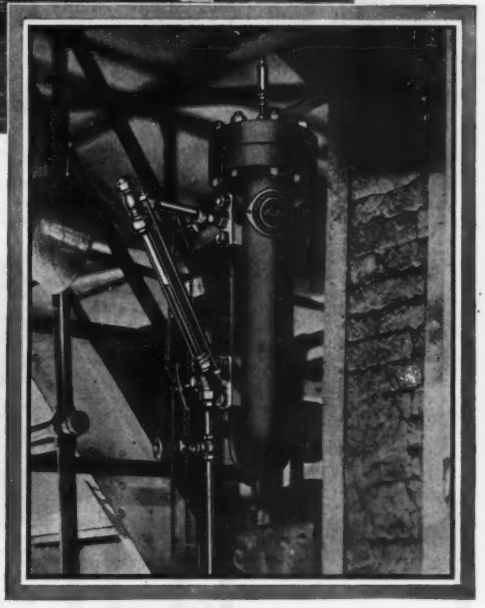
YARWAY





Above—
Covington, Virginia, Mill of the West Virginia Pulp and Paper Company.

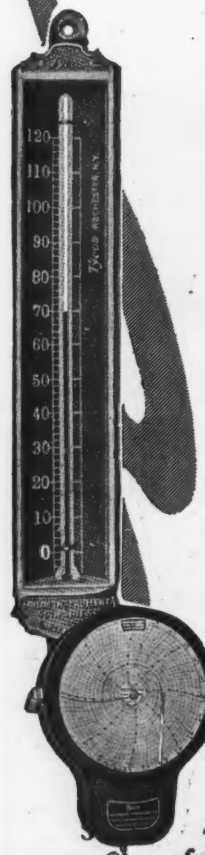
At Right—
A YARWAY FLOATLESS HI-LO ALARM WATER COLUMN and YARWAY-SESURE INCLINED WATER GAGE on one of boilers at the Westvaco Covington Mill. Types of each are available for all working pressures up to 600 lbs.



BOILER DEVICES

Tycos
TEMPERATURE INSTRUMENTS
Indicating-Recording-Controlling

serve on Economizers, Steam Lines, Turbines, Condensers, Heaters in Leading Stations



Just as *Tycos* have been called upon throughout industry, the sciences and arts, to furnish accurate temperature indications and records, so the power plant field turns to *Tycos* for like services on extreme temperatures developed in the modern plant.

75 Years' experience enables instruments bearing the name of *Tycos* or *Taylor* to furnish the invaluable information on temperatures and pressures that are necessary to economy and continuity of power generation.

There is one for every purpose and the *Tycos* catalogue for steam power plants shows them and their many applications. Write for a copy.

"the SIXTH Sense of Industry"

Taylor Instrument Companies
ROCHESTER, N.Y., U.S.A.

CANADIAN PLANT TYCOS BUILDING TORONTO

MANUFACTURING DISTRIBUTORS IN GREAT BRITAIN SHORT & MASON, LTD., LONDON

Send for free copy for your guidance

Calumet Station of the Commonwealth Edison Company, Chicago, where Tycos Instruments are used.

Double Service

Both feed pump and boiler are protected by the automatic operation and the positive action of the

STRONG Type E Pump Governor

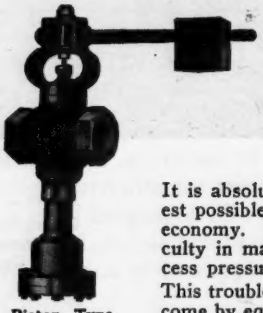
Maintains given excess pressure above the boiler pressure regardless of boiler pressure fluctuation. Excess pressure is reduced and increased by means of an adjusting nut.

Steam pressure, pump discharge and a solid piston in a cylinder are the operating elements.

NO Arms or Weights

NO Levers Toggles

The Strong, Carlisle & Hammond Co.
Manufacturers of a Complete Line of
Steam, Radiator and Vacuum Traps, Steam and Oil Separators, High and Low Pressure Reducing Valves, Pump Governors, Engine Stops, Emergency Check Valves, Evrtyte Globe Valves, etc.
1392-94 W. Third St., CLEVELAND, OHIO



Piston Type

CONSTANT Excess Pressure On the Feed Line is BEST

It is absolutely necessary for highest possible operating efficiency and economy. Have you had any difficulty in maintaining a FIXED excess pressure on your feed lines? This trouble can be completely overcome by equipping your feed pumps with

FULTON
Boiler Feed Pump GOVERNORS

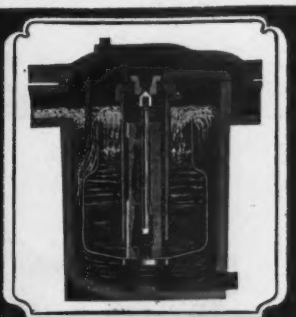
They automatically maintain a CONSTANT difference between the pressure in the feed pipe and the pressure in the boilers. No matter how the steam pressure varies, this excess will always remain constant. The speed of the pump is automatically regulated according to the requirements of the boiler. When little water is needed, the governor cuts down the pump speed by throttling its steam supply, and vice versa.

Absolutely reliable in operation. Made in two types—piston and diaphragm.

Ask for Bulletins

The Chaplin-Fulton Mfg. Co.
28-40 Penn Avenue, Pittsburgh, Penna.
Also Manufacturers of the Vigilant Feed Water Regulator

ILLINOIS Eclipse TRAP



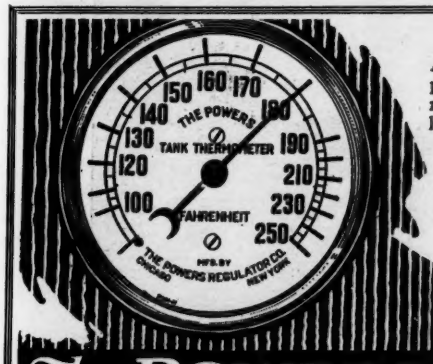
Only TWO Moving Parts

Valve ALWAYS tight closed or wide open—NEVER cracked on seat—positive SNAP action—wire drawing impossible—can't blow steam or air-bind.

Test one on your WORST service—you will be amazed at the results. We'll pay all transportation costs if it doesn't end your trap troubles.

Order one on 60-day free trial or write for Bulletin 33—Today

ILLINOIS ENGINEERING COMPANY, CHICAGO



EASY TO READ

A time and money saver for instantly, correctly, and plainly indicating temperatures. Best thermometer made for hot water tanks, pipe lines, etc. Made with horizontal or vertical stem.

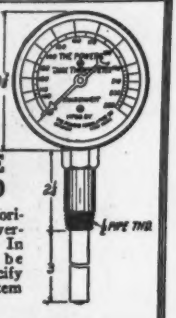
Easy to read as a clock. Sturdily made, entirely of brass, case finished in nickel plate, with silver dial and black figures. No brittle glass tubes, no eyestrain, no guesswork. *Write for bulletin.*

THE POWERS REGULATOR CO.

36 years of specialization in temperature control

2769 Greenview Ave., Chicago

Also New York, Boston, Toronto, and 31 other offices. See your phone directory. (4000A)



LIST PRICE $12.00

for either horizontal or vertical stem. In ordering be sure to specify what type stem you need.

The POWERS DIAL THERMOMETER

AMERICAN

INDICATING PRESSURE GAUGES

for pressure, vacuum and draft. Have extra heavy, long wearing, non-corrosive movement. Dial is hand calibrated, insuring accuracy. White enameled matt finish eliminates glare and makes reading easy. Write for Catalog A-34.

AMERICAN SCHAEFFER & BUDENBERG CORP.

338 Berry St., Brooklyn, N. Y.

Atlanta	Minneapolis	Salt Lake City
*Boston	Philadelphia	*San Francisco
Buffalo	*Pittsburgh	*Seattle
*Chicago	Houston	St. Louis
Cleveland	*Los Angeles	*Tulsa
Detroit		

*Stock carried at these branches.

Engine Stops

Mechanical and Electrical

Send for Catalogue

LOCKE REGULATOR CO.

Salem, Mass.

PICKERING GOVERNORS

For AIR COMPRESSOR UNLOADERS

Among the prominent builders of air compressors who have adopted the Pickering Unloader Governor are the Chicago Pneumatic Tool Company, Pennsylvania Pump & Compressor Company, the Sullivan Machinery Company. Others are experimenting with it with the view to its adoption.

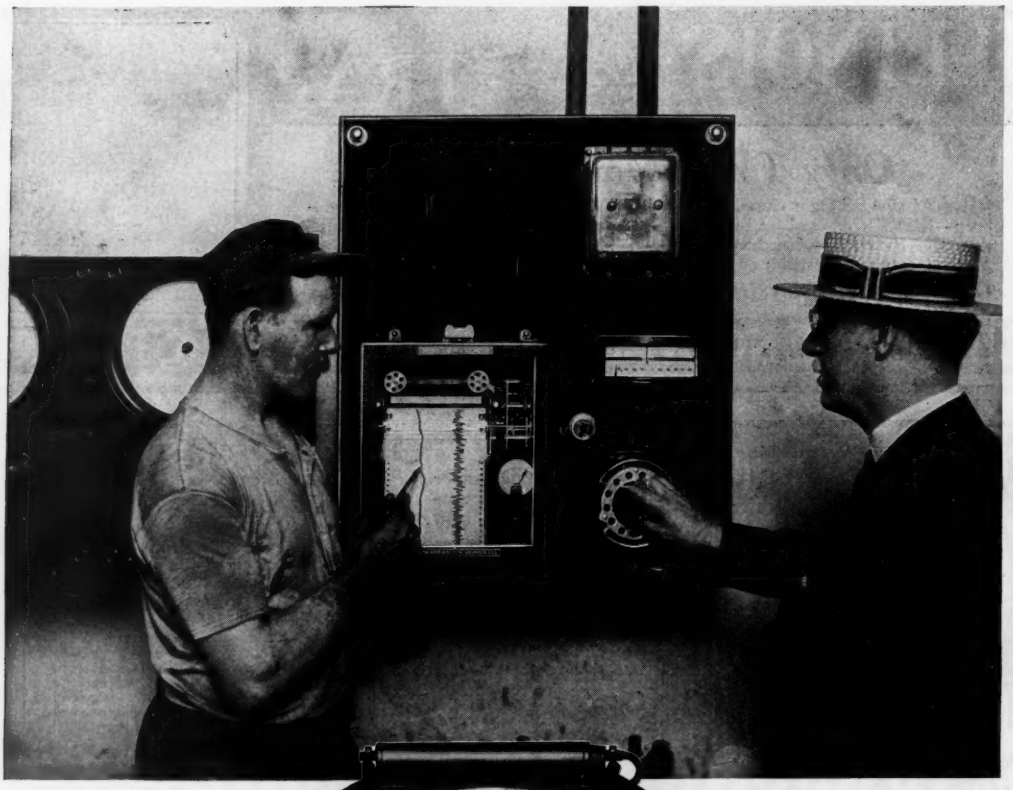
Unfailing dependability—under severe and continuous duty—is the reason why. And it is the reason why Pickering Governors are well represented in every industry, why they are found on steam engines, steam turbines, Diesel engines, oil engines, electrical controls, air compressors, gasoline tractors, water wheels, recirculating Vano blowers, stokers, refrigerating units, cream separators, etc.

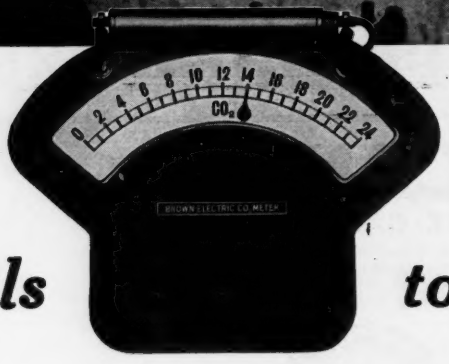
Pickering Engineers will gladly confer with you regarding power control problems in your plant. Send for booklet 21-N.

"Governor Builders Since 1860"

THE PICKERING GOVERNOR CO.

PORTLAND, CONN.





No chemicals to fuss with . .

No more doubtful results. The Brown Electric CO_2 Meter has brought continuous accuracy and simplicity to what has been a complex nuisance. Thanks to its thermal-conductivity principle.

Just watch the indicator or read the chart in the recorder, which may be located at the boiler, in the office, or wherever convenient.

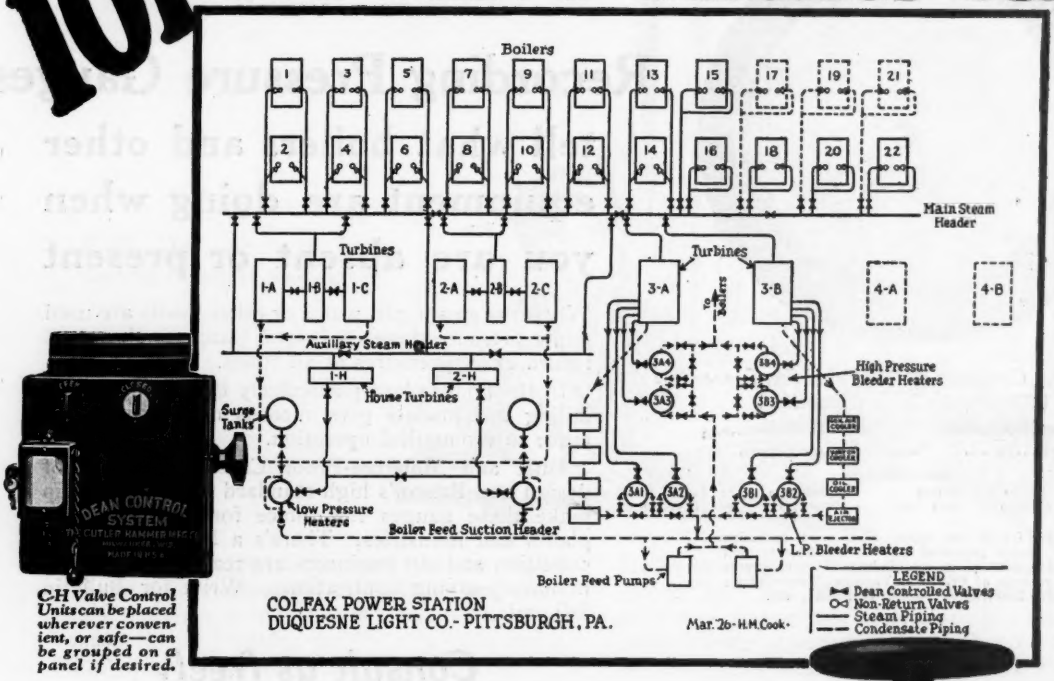
With a Brown CO_2 Meter you can read your combustion conditions at all times with an indicator or recorder. The illuminated dial, "boiler front" type of Brown Indicating CO_2 Meter is illustrated above.

Fully explained in Catalog 33. Yours for the asking. The Brown Instrument Company, 4402 Wayne Ave., Philadelphia. *Branch Offices in 18 Principal Cities.*

"To Measure is to Economize"-Pascal

Brown Electric CO_2 Meter

101 C-H Valve Control Units



C-H Valve Control Units can be placed wherever convenient, or safe—can be grouped on a panel if desired.

—make this modern plant efficient, safe

See C-H Valve Control at the Chicago Power Show Booths 110, 111, 112

ONE of the leading power plants in the country operates 101 valves with C-H Motor Operating Valve Units. This endorsement by such extensive use followed the rigid test of performance. C-H Valve Control System proved more efficient, safer than hand operation could possibly be.

Any valve, in any location, responds instantly to the touch of a finger to the control station which is placed in a convenient, safe spot. Valve operation is a matter of seconds and where needed, "fool-proof" interlocks can be arranged for following any desired sequence of valve operation.

Isn't a thorough investigation of such valve control well worth while? Just write for the booklet "Modern Valve Control Practice".

The CUTLER-HAMMER Mfg. Co.

Pioneer Manufacturers of Electric Control Apparatus

1253 St. Paul Avenue - MILWAUKEE, WISCONSIN

C-H Valve Operating Units can be installed on any valve—new or already in service—usually without shutting down the line.

CUTLER C-H HAMMER

Dean Valve Control System

The Bristol Company Waterbury, Connecticut

FOR 38 YEARS MAKERS OF

BRISTOL'S RECORDING INSTRUMENTS

Branch Offices:

Birmingham Boston Denver Chicago Detroit New York Philadelphia Pittsburgh St. Louis San Francisco

BRISTOL'S—the name of a most extensive and highly perfected line of instruments that meet power plant and industrial requirements for records of Pressure, Vacuum, Temperature, Draft, Electricity, Speed, Humidity, etc.

TRADE MARK

BRISTOL'S

REG. U. S. PAT. OFFICE.

Recording Pressure Gauges

tell what boilers and other equipment are doing when you are absent or present

Wherever steam, air, water or other media are used under pressure there's a Bristol Gauge to show and record exact pressures at all times.

In the boiler plant particularly these rugged, unfailing instruments give records of prime importance to economical operation.

Dust and Moisture-Proof Cases, simplicity of design and Bristol's high standard of workmanship make these gauges the choice for leading power plants and industries. There's a Model for every condition and our engineers are ready to assist you in money-saving applications. Write for Bulletin 360 and

Consult us freely

Greetings of the Season

to the engineers of the world to whom we are now completing our forty-seventh year of service with the hope of your increasing prosperity and that we may continue to serve you better

The Fisher Governor Co., Inc.

693 Fisher Building Marshalltown, Iowa

1927 1928

In life-long partnership with "WESTONS"

"Well, Dad, at least I'm starting in where you did—"

"YES, Tom, almost identically! You're rigged out a little differently as to clothes and trappings; but there is one point of similarity between us, as you and I tackled the first day's job, that's important—*we both partnered with a* WESTON!

"Senior and Junior—D. C. and A. C.—with a sweep of forty years between. And yet my old Weston Model ONE is as hale and hearty as ever. They simply can't down us old fellows, Tom, and I take a lot of comfort in the fact that all your modern scientists haven't discovered anything better than Dr. Weston's original principle of the permanent magnet, movable coil. It has been copied in every country in the world, but in forty long years no one has ever produced its equal.

"Forty years of knowing how—building brick upon brick of experience—has made the Weston institution the acknowledged measuring authority of the entire electrical industry throughout the world.

"And therein lies a lesson, Tom. The one best way to rise to the top in our profession is to be a little more conscientious, more accurate, than our fellows. Such was Weston's guiding principle that led him on and on past every obstacle until he had attained every objective and arrived at those amazing discoveries which revolutionized the electrical measuring art, and established its permanent standards. This is why *it must be right to be a "Weston."*

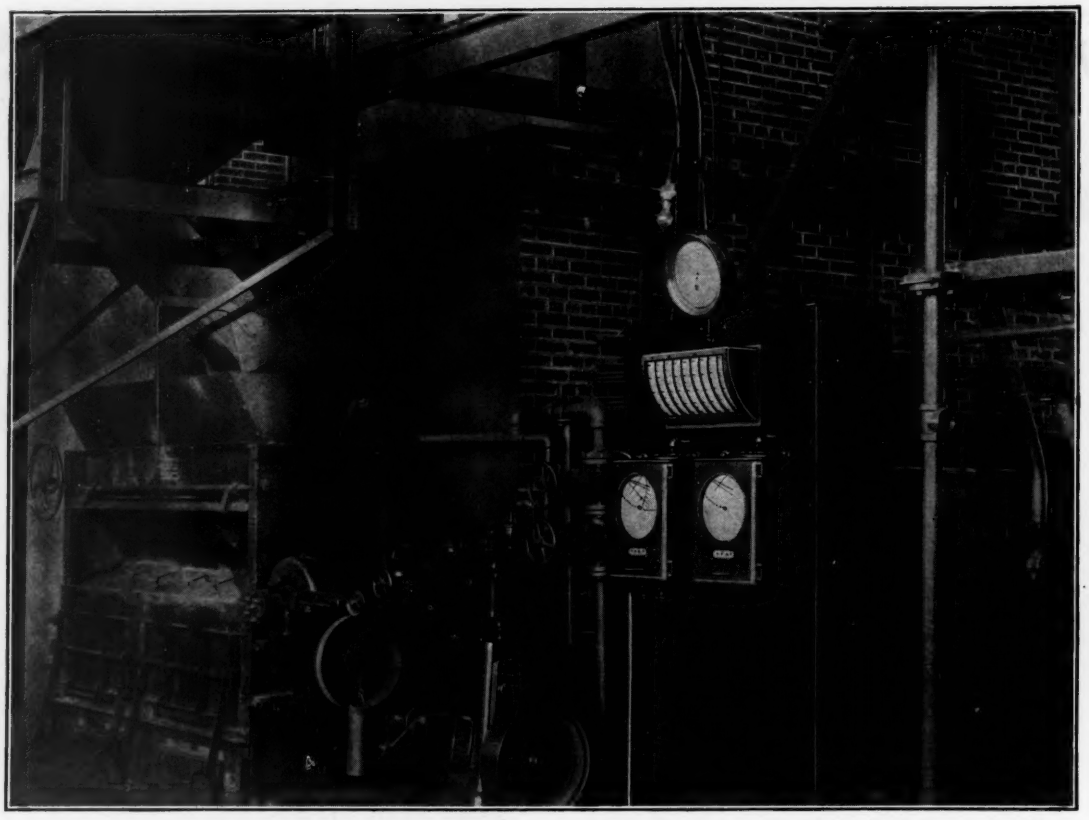
"It is that same principle which guides the Weston organization today, endowing it with that same vital force, ever urging on its matchless craftsmen to achieve a more delicate artistry in the individual task.

"It is a unique institution—built upon infinite patience and minutest detail, hundreds of microscopic operations, thousands of inconceivably fine parts, and fractions of thousandths of an inch working tolerance.

"And the A. C. Junior Instrument that you are taking to your first assignment, inherits those attributes. You are starting in where I did, Tom, and if you will pattern after and partner only with "Westons" half your battles will be won."

WESTON ELECTRICAL INSTRUMENT CORPORATION
138 Weston Avenue **Newark, New Jersey**

Weston
PIONEERS SINCE 1888
INSTRUMENTS



Bailey Meters Increase Boiler Efficiency

They show exactly what the operating conditions are at every instant and they furnish the necessary information for correcting faulty conditions as soon as they occur, so that maximum economy may be maintained at all times.

The Steam Flow part of the meter accurately measures the amount of steam being generated at all times. This is shown by a red record and reads in per cent of boiler rating or pounds of steam per hour. The Air Flow part of the meter records the rate of flow of air through the furnace in blue. This Air Flow reading is not given in terms of cubic feet or weight of air, but is relative to the amount of steam being produced. The two records of Steam Flow and Air Flow should always be together and show the same reading regardless of the load being carried by the boiler. This indicates that the proper amount of air is being used for combustion.

Write for Bulletins 43 and 43A

BAILEY METER COMPANY

1040 Ivanhoe Road, Cleveland, Ohio

Bailey Meter Company, Limited, Montreal, Canada

Says the Chief Engineer

"When I got my license back in '99, nobody thought much of combining bookkeeping with steam engineering. In those days the superintendent didn't come bothering a man about 'percentage of efficiency in production of steam'. Now, by George, they want to know exactly,—and you can't depend on instinct or on a fireman's guesses for that. No sir, rule of thumb is out of date. Today, with competition so keen, the motto is 'make every penny count.'

"I'm not kicking, though. They put in Republic Flow Meters and I can split decimal points with them now. Run my power plant like other departments?' says I. 'All right, gentlemen. The boiler room has nothing to lose from records.' Fact is, we gain. I was going to demand a new boiler, but by watching the meters I can distribute the load so we don't need it,—not this year. When we do, my records will get it for me.

"I got gray-headed guessing about steam, then worrying about my guesses. But I don't even 'estimate' any more, using Republic Flow Meters. I know."

P. S. The Accountant will talk to you next month.

"Bulletin Steam Economy Mailed on Request"

Republic Flow Meters Co.

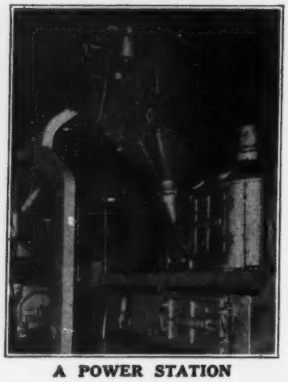
Factory and General Offices, 2224 Diversey Parkway

CHICAGO, U. S. A.

RICHARDSON

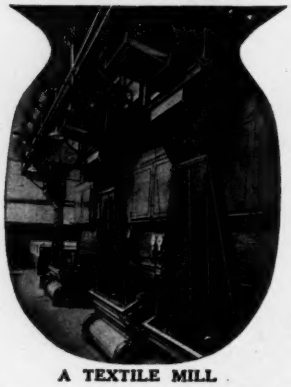
Automatic Coal Scales

at
Duquesne Light Co.
Pittsburgh



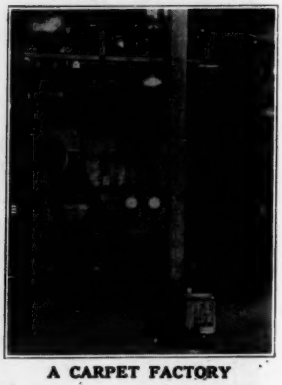
A POWER STATION

at
Wilkes-Barre Lace Mfg. Co.



A TEXTILE MILL

at
Stephen Sanford & Sons,
Amsterdam, N. Y.



A CARPET FACTORY

Accurately record the fuel consumed by each boiler or pulverizer. They keep pace with the consumption and the records available enable the operators to detect at once any waste of coal or loss in efficiency of operation.

Weigh your coal to *each* boiler and obtain maximum efficiency at all times. Prevent loss by over-consumption! Ask for Bulletin 9127.

RICHARDSON SCALE COMPANY
Clifton, New Jersey

Pittsburgh New York Boston Chicago Omaha Wichita Minneapolis Los Angeles Gulfport Philadelphia

A MINUTE WITH VENTURI

The Dependable Boiler Feed Meter that

RECORDS
the rate of flow on a large daily chart reading directly in pounds per hour.
The entire chart record is visible.

REGISTERS
the total flow. All dials graduated in a clockwise direction.
Totals easily and correctly read.

INDICATES
the rate of flow in pounds per hour or the boiler horsepower on a dial 30 inches in circumference. Graduations are most widely spaced where used most frequently.
Easy to read as a clock.

Note the three separate dials. Engineers will appreciate this feature.
You will want a copy of Bulletin 93.

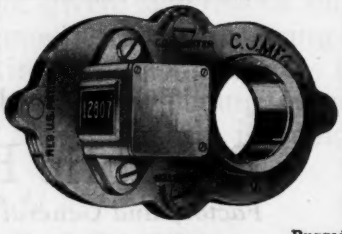
BUILDERS IRON FOUNDRY
PROVIDENCE, R.I.
VENTURI
"VENTURI" Registered

ELECTRICAL CO_2 METERS

With An Unqualified
GUARANTEE

Practice and Theory Interestingly Explained in Bulletin I-781.
Send for Your Copy.
For Automatic Combustion Control Ask for Bulletin I-660.

LEEDS & NORTHRUP CO.
4901 STENTON AVENUE, PHILADELPHIA



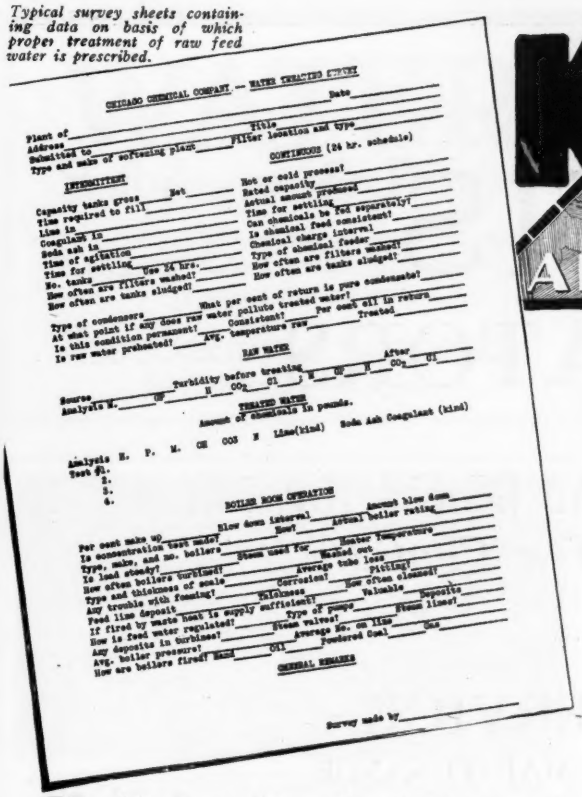
Invest $25 and save that much every month!

C. J. Coal Meter sent for free trial

Write for bulletin

Rugged, accurate and tamperproof, the C. J. Coal Meter attaches to any stoker having a revolving shaft. Its records of coal burned result in immediate improvement in firing.

C. J. Mfg. Co.
3427 N. 5th St.
Philadelphia, Pa.



CHICAGO CHEMICAL COMPANY — WATER TREATING EXPERT

Plant of _____ Date _____
Address _____
Submitted to _____ Title _____
Type and make of softening plant _____ Filter location and type _____

INTERMITTENT — CONTINUOUS (24 hr. schedule)

Capacity tanks gross _____ Net _____ Hot or cold process? _____
Time required to fill _____ Rated capacity _____
Lime in _____ Actual amount produced _____
Coagulant in _____ Time for settling _____
Soda ash in _____ Can chemicals be fed separately? _____
Time of agitation _____ Is feed consistent? _____
Time for settling _____ Hrs. Is chemical charge interval _____
No. tanks _____ Chemical charge interval _____
How often are filters washed? _____ Type of chemical feeder _____
How often are tanks sludged? _____ Type of chemical feeder _____
How often are filters washed? _____
How often are tanks sludged? _____

Type of condensers _____ What per cent of return is pure condensate? _____
At what point if any does raw water pollute treated water? _____
Is this condition permanent? _____ Consistent? _____ Per cent oil in return _____
Is raw water preheated? _____ Avg. temperature raw _____ Treated _____

RAW WATER — After

Source _____ Turbidity before treating _____
Analysis M. _____ HP _____ H _____ CO2 _____ Cl _____ H _____ HP _____ H _____ CO2 _____ Cl _____

TREATED WATER

Amount of chemicals in pounds.

Analysis M. P. M. OH CO3 H Lime(kind) Soda Ash Coagulant (kind)
Test #1.
2.
3.
4.

BOILER ROOM OPERATION

Blow down interval _____ Amount blow down _____
Per cent make up _____ Now? _____ Actual boiler rating _____
Is concentration test made? _____
Type, make, and no. boilers _____ Steam used for _____ Heater Temperature _____
Is load steady? _____ Heated out _____
How often boilers turbined? _____ Average tube loss _____
How often boilers cleaned? _____ Corrosion? _____ Pitting? _____
Type and thickness of scale _____
Any trouble with foaming? _____ Thickness _____
Feed line deposit _____ Type of pumps _____ Valuable _____ Deposits _____
If fired by waste heat is supply sufficient? _____ Steam lines? _____
How is feed water regulated? _____ Steam valves? _____
Any deposits in turbines? _____ Average No. on line _____ Use _____
Avg. boiler pressure? _____
How are boilers fired? Hand _____ Oil _____ Powdered Coal _____

GENERAL REMARKS

Survey made by _____

Typical survey sheets containing data on basis of which proper treatment of raw feed water is prescribed.

K.W.S.

REG. U.S. PAT. OFF.

SODIUM ALUMINATE

Every K. W. S. sale is based on a scientific survey

K. W. S. sodium aluminate is not just sold—it is serviced. When K. W. S. chemists are convinced that important plant economies can be effected by its use they will recommend it to you. Their opinions are based on a thorough, scientific survey of your boiler plant, source and composition of the raw feed water and method of treating employed at the time.

Proper treatment of the raw feed water is prescribed on the basis of the data obtained. Efficient treating of the water is maintained by a simple scientific method developed by this company which enables your engineer at all times to check on the requirements of the feed water. Not only that, but this company, by regular calls of its service men and by mail, sees to it that K. W. S. is being used to produce the results of which it is capable.

K. W. S. sodium aluminate in combination with soda ash and lime, the ordinary chemicals used in external treatment, enables them to react more quickly and completely, leaving a coagulated precipitate which is easily removed by filters or by the blow-down when treating in the boilers.

When you hear an engineer speak of sodium aluminate, he means K. W. S. sodium aluminate because this is the first solution of sodium aluminate and was made possible by the patented process owned by this company. We will gladly send literature describing the use of this product. Please give your company name, and state whether interested in external or internal treatment.

CHICAGO CHEMICAL CO

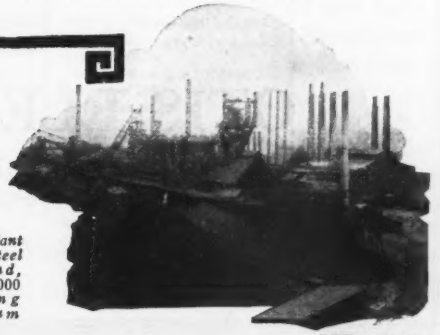
WATER TREATING AND CLARIFYING ENGINEERS

6224 W. 66th Place

CHICAGO

Specialists in water softening, filtration, process work, waste water disposal, and all problems involving water supply and treatment.

Representatives in Principal Cities



Blast furnace plant of the Otis Steel Co., Cleveland, Ohio, one of 2000 plants using K. W. S. sodium aluminate.

PPE 12-15 Gray

OTIS
ELEVATORS

The Standard of the World for Three Quarters of a Century

OTIS-SERVICE

INSPECTION and MAINTENANCE

There are 178 Otis offices throughout the United States where skilled mechanics and stocks of repair parts are available, giving owners the class of service to which they are entitled by their purchase of this high grade elevator equipment.

OVER 25,000 ELEVATORS IN ALL PARTS OF THE COUNTRY ARE UNDER SOME FORM OF OTIS-SERVICE

Ask Our Nearest Office

OTIS ELEVATOR COMPANY

OFFICES IN ALL PRINCIPAL CITIES
OF THE WORLD

WATER
Softeners & Filters

Iron and Oil Removal Apparatus–Filtration Equipment–Water Conditioning Apparatus of every description

The Permutit Company
440 Fourth Ave. New York

PAIGE-JONES
WATER SOFTENING
and FILTRATION

Upward Flow Zeolite Water Softeners
Lime Soda Water Softeners
Pressure Sand Filters
FFF Boiler Feed Water Treatments
Household Water Softeners
Write for Bulletins

PAIGE & JONES CHEMICAL CO. *Inc.*
General Sales Office · Technical Dept. & Works · HAMMOND · INDIANA
Executive Offices · 461 FOURTH AVE. NEW YORK . *Offices in Principal Cities*

Put Hawk-Eye Compounds into the boilers and save *coal in the bins!*

"Accept No Substitutes"

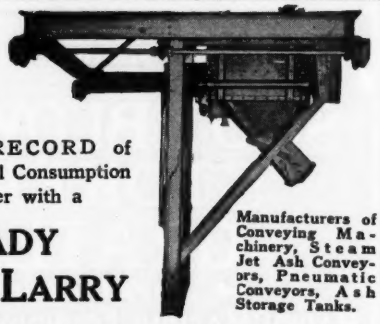
We'll gladly specify the right Hawk-Eye Compound for your conditions, lend you the feeding attachment and thereafter your boilers will be scale-free. Only 1 lb. per day necessary for 100-hp. boiler.

For 30 Years

Hawk-Eye Compounds have been saving coal in power plants. It's clean and dry —easy to handle, comes in squares marked off into eight 1-lb. bricks.

HAWK-EYE COMPOUND CO. (Not Inc.)
Blue Island, Ill.

KEEP A

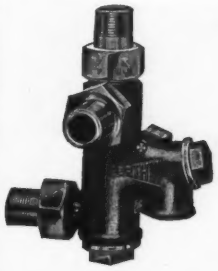


PRINTED RECORD of Your Daily Coal Consumption of EACH Boiler with a

BRADY WEIGH LARRY

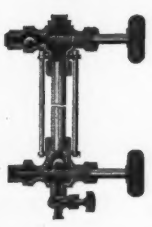
Manufacturers of Conveying Machinery, Steam Jet Ash Conveyors, Pneumatic Conveyors, Ash Storage Tanks.

The Brady Conveyors Corporation
20 W. Jackson Blvd., Chicago, Ill.



The Line for Service

PENBERTHY PRODUCTS



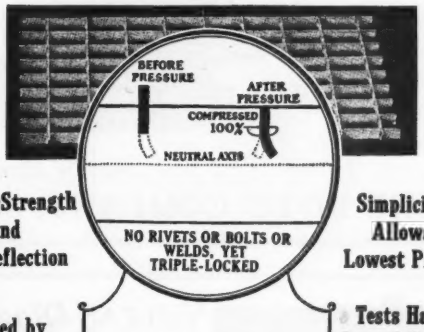
Automatic Injectors
are quick to start. Restart themselves if water supply is temporarily interrupted. 1,500,000 have been sold.

"Safeguard" Automatic Water Gage
protects men and boilers by instantly shutting off steam and scalding water when a glass breaks. Opens as soon as new glass is inserted.

Automatic Cellar Drainer
protects operation in time of flood or overflow. Always primed and ready to start instantly.
Write for literature on these and other Penberthy Products.

Penberthy Injector Company
1238 Holden Ave., Detroit, Mich.
Established 1886
Canadian Plant Windsor, Ont.
New York Depot 71 Beekman St.

TRI-LOK
"KING OF THE WALK"
GRATING AND TREAD



Greater Strength and Less Deflection

Simplicity Allows Lowest Prices

NO RIVETS OR BOLTS OR WELDS, YET TRIPLE-LOCKED

What a difference *three locks* make!
First, there is a right-twist lock in every other bar.
Second, there is a left-twist lock in alternate bars.
Third, there is the 1600-ton hydraulic pressure-lock, which is effected by *pressing* the cross bars into the two twist-locks.
Time nor wear can not open the three locks of TRI-LOK.

Approved by The Foremost Engineers and Architects

Tests Have Proved Joints Stronger than Steel Itself

Warehouse Deliveries in New York City

Agencies in Principal Cities of the United States

Ventilated Steel Flooring

THE TRI-LOK COMPANY 5539 BUTLER STREET PITTSBURGH, PA.

Patent Applied For

Leakless under pressures up to 1000 lbs.

Quick-opening and self-closing, this is the latest development of the original "PBH" Weighted Gauge Cock. On pressures up to a 1,000 lb., it holds tight and with its renewable monel metal valve stem and seat will outlast the boiler itself. Write.

"P.B.H."
Extra Heavy
Gauge Cock

sent for a reasonable trial on request. Write for bulletin.

The Paul B. Huyette Co., Inc.
Suite 3, No. 5 So. 18th St.
Philadelphia, Pa.
New York Office: 149 Broadway
Springfield, Mass., Wilkes-Barre Pa., Washington, D. C.

The Sign of Better Specialties

Chase the Soot and Save Repairs by Using

PILLEY'S

Combination Flue Brush and Scraper

It is an efficient tool which removes the soot and scale and leaves the tubes shining like new.

The PILLEY is easy to operate. One turn of the handle contracts the scraper so that it will easily enter the tube. A turn in the opposite direction expands it to full size so that it comes in direct contact with the soot. The iron scraper breaks off the crust and the fine wire brush sweeps it out leaving the tube perfectly clean.

Pilley's Combination Flue Brush and Scraper not only saves repairs, it saves Coal, also.

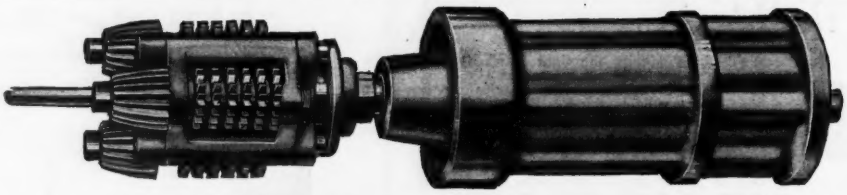
Made in all sizes from 2 inches to 6 inches. Price $1.00 per diameter inch. Your Jobber Sells Them.

Pilley Packing & Flue Brush Mfg. Co.
611 S. Third St., St. Louis, Mo.
71 Fulton St., New York, N. Y.

Diamond
AUTOMATIC VALVED
SOOT BLOWERS
Save 1 *carload of coal out of* 16
Diamond Power Specialty Corporation
Detroit-Michigan

There Is a Difference In Dollars In Your Power Cost

Clean your boilers as often as you can, instead of only when you must



Roto 4" Heavy Duty Air-Driven Tube Cleaner

THE ROTO COMPANY, Sussex Ave. and Newark St., NEWARK, N. J.

VULCAN *Diagonal* Method of Blowing

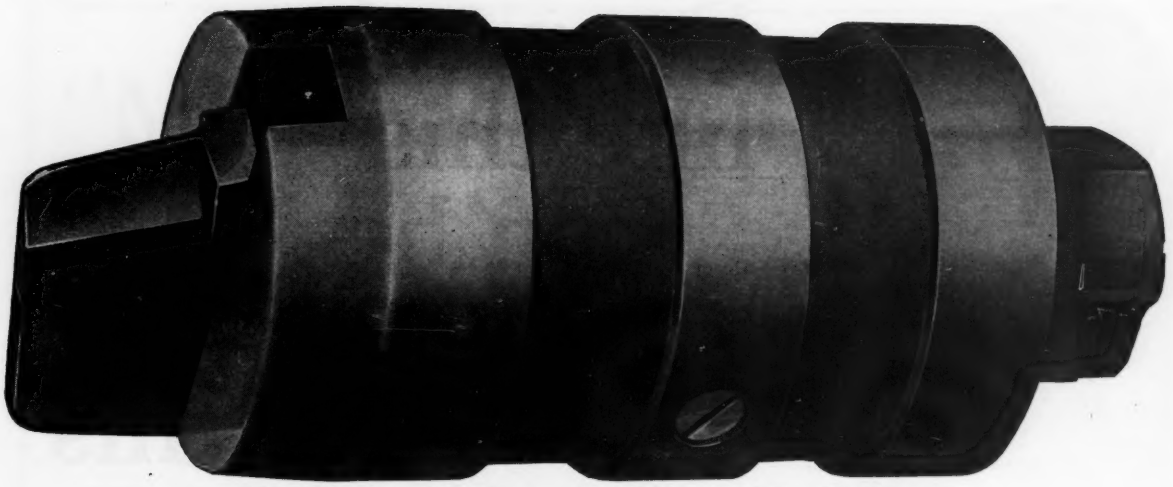
takes advantage of the diagonals formed by the tubes, in the staggered tube type of boilers, through which cleaning jets of steam can pass, scrubbing along the tubes clear to the bottom row, but never directly against them.

Special bulletins describing Vulcans for various types of boilers will be gladly sent on request.

Vulcan Soot Cleaner Co.
Vulcan Bldg., Dubois, Pa.

THE MARION LINE

SOOT BLOWERS
STOKERS
GRATES
→ *Save the coal* ←
MARION MACHINE FOUNDRY & SUPPLY CO.
MARION, INDIANA



No. 20 Special Dean for Water Tube Boilers
(Built for 4″ tubes only)

Try This Super Cleaner
In Your Water Tube Boilers

Users say they've never seen anything like the No. 20 Dean for 100% effectiveness in removing scale from the tubes of water tube boilers.

The No. 20 Dean does perfect work even in the hands of unskilled help.

Anyone can operate it. Just push it through the tubes. The No. 20 Dean cannot fail to remove every bit of scale.

The prolonged shell makes the No. 20 Dean foolproof.

Simple and rugged. Almost unbreakable. Cost of maintenance is insignificant.

Dislodges, not only scale from the inside, but soot deposit from the outside of the tubes—a feature possessed by no other cleaner except the Dean.

For a revelation of what a tube cleaner ought to be, try a No. 20 Dean in your water tube boilers. (The No. 20 Dean is built for 4″ tubes only.)

Ask about our free trial offer.

The Wm. B. Pierce Co.
149 Ellicott St. Buffalo, N. Y.

Manufacturers of the
Dean Boiler Tube Cleaner
for

Return tubular boilers	Loco. tubes
Water tube boilers	Evaporators
Curved tube boilers	Economizers

Are your surface condenser tube cleaning methods all they should be?
OUR
CONCO CONDENSER TUBE CLEANERS
Scrape—Not rub—the tubes clean

Even tubes like this can be cleaned with this LAGONDA CLEANER

In days past, boiler tubes in the condition pictured above were not uncommon. Even today, due to lack of attention or very bad scale-forming conditions, boiler tubes occasionally become heavily clogged.

The most hopelessly scaled tubes—if straight—can be cleaned with the Lagonda Direct Motor Cleaner illustrated to the right. The big motor has the power, and the cutting head the ability, to plow through solid scale if need be.

A number of plants use this type of cleaner exclusively, due to the hard scale encountered, and because this cleaner works much faster than the ordinary turbine cleaner, thus cutting down the time of cleaning. It has been a salvation for many concerns where the boilers have become scaled beyond the power of the standard type of cleaner to combat. For all ordinary scale conditions the turbine type of Lagonda Cleaner which enters the tube is perfectly satisfactory.

Catalog X-9 describes standard types of Lagonda Cleaners for all sizes and types of tubes as well as this heavy-duty cleaner, condenser cleaners, etc. A copy should be in your files.

If it's a tube, it needs regular Lagonda cleaning

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO
FUEL SAVING SPECIALISTS

NEW YORK, CHICAGO, PHILADELPHIA, BOSTON, PITTSBURGH, CLEVELAND CINCINNATI, DETROIT, SYRACUSE, BALTIMORE. ST. LOUIS, KANSAS CITY, DENVER, DALLAS, ATLANTA, SAN FRANCISCO, MONTREAL, LONDON.

X-1420

Besides cleaners for all sorts of tubes in boilers, condensers, heaters, evaporators, oil stills, etc., Lagonda makes a boiler tube cutter which should be in every boiler room, a reseating machine for caps and headers, and a cleaner feeding device for cleaning curved tube boilers from the outside of the drum.

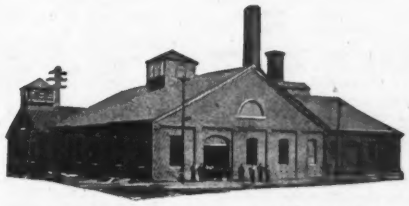
"MODERN" PLANTS

True as in 1894

STONE & WEBSTER, Inc., built a station in 1894. An account, "A Modern Power Plant," contains these words:

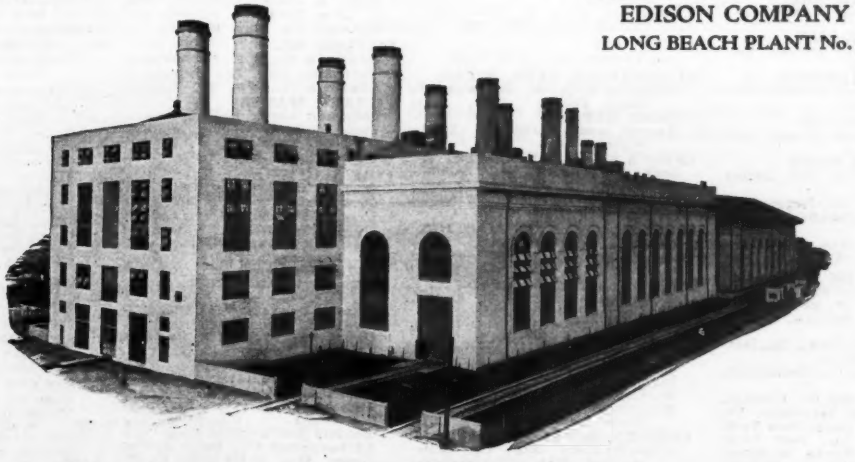
> A complete mechanism, every part designed to work with every other part . . . in case of accident to any member, some other can perform its duty . . . energy put on the line surely and cheaply . . . must be no shutdowns, either steam or electrical . . . every device and arrangement a good investment . . . constructed and equipped under constant supervision and care.

Written when 2000 kw. was an important installation, this remains a good description of Stone & Webster power work. It shows the sound early foundation on which rests the experience offered Stone & Webster clients today.



INDUSTRIAL IMPROVEMENT COMPANY OF BOSTON
OLD ALLENTOWN, PA., PLANT

SOUTHERN CALIFORNIA EDISON COMPANY
LONG BEACH PLANT No. 2



STONE & WEBSTER
INCORPORATED

DESIGN · BUILD · OPERATE · FINANCE

BOSTON, 49 Federal Street
NEW YORK, 120 Broadway
CHICAGO, First National Bank Bldg.
PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Holbrook Bldg.
PITTSBURGH, Union Trust Bldg.

COAL BUNKERS, CAST IRON, CATENARY
Allen-Sherman-Hoff Co., Phila.

COAL CRUSHERS
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., Columbus, O.
Pennsylvania Crusher Co., Phila.
Stephens - Adamson Mfg. Co., Aurora, Ill
Strong-Scott Mfg. Co., Minneapolis, Minn.
Webster Mfg. Co., The, Chicago.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.

COAL STORAGE EQUIPMENT
Allen-Sherman-Hoff Co., Phila.
Brady Conveyors Corp., Chicago.
Link-Belt Company, Chicago.
Stephens - Adamson Mfg. Co., Aurora, Ill
Webster Mfg. Co., The, Chicago.
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

COAL WEIGHING AND MEASURING EQUIPMENT
C. J. Mfg. Co., Philadelphia.
Richardson Scale Co., Clifton, N. J.
Webster Mfg. Co., The, Chicago.

COATINGS, PROTECTIVE
Dampney Co. of Am., Boston.

COCKS, AIR AND STEAM
Dart Mfg. Co., E. M., Providence, R. I.
Homestead Valve Mfg. Co., Homestead, Pa.
Powell Co., Wm., Cincinnati, O.
Williams Valve Co., D. T., Cincinnati, O.

COCKS, BLOW OFF
Scully Steel & Iron Co., Chicago.

COILS AND BENDS
Grinnell Co., Inc., Providence.
National Pipe Bending Co., New Haven, Conn.

COMBUSTION APPLIANCES
Brown Instrument Co., Phila.

COMBUSTION CONTROL SYSTEMS
Hagan Corp., Pittsburgh.

COMBUSTION ENGINEERS
Boiler Engrg. Co., Newark, N. J.

COMBUSTION (CO_2) RECORDERS
Brown Instrument Co., Phila.
Huyette Co., Inc., The Paul B., Philadelphia.
Leeds & Northrup Co., Phila.
Permutit Co., New York.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago, Ill.

COMMUTATOR DRESSER.
Ideal Commutator Dresser Co., Sycamore, Ill.

COMMUTATOR CEMENT.
Ideal Commutator Dresser Co., Sycamore, Ill.

COMMUTATOR SLOTTERS.
Ideal Commutator Dresser Co., Sycamore, Ill.

COMMUTATOR STONES.
Ideal Commutator Dresser Co., Sycamore, Ill.

COMPOUND PIPE JOINT
Dixon Crucible Co., Jos., Jersey City, N. J.
Smooth-On Mfg. Co., Jersey City.

CONCRETE ARMORING SURFACE
Irving Iron Works Co., Long Island City, N. Y.

CONDENSER TUBE CLEANERS
Lagonda Mfg. Co., Springfield, O.
Pierce Co., Wm. B., Buffalo, N.Y.
Roto Co., The, Newark, N. J.

CONDENSERS
American Steam Pump Co., Battle Creek, Mich.
Bethlehem Steel Co., Bethlehem, Pa.
Binks Spray Equip. Co., Chicago.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Ingersoll-Rand Co., New York.
Manistee Iron Works, Manistee.
Ross Heater & Mfg. Co., Buffalo.
Schutte & Koerting Co., Phila.
Superheater Co., New York.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

CONSULTING ENGINEERS
Stone & Webster, Inc., Boston.

CONVEYORS
Brady Conveyors Corp., Chicago.
Combustion Engrg. Corp., N. Y.
Detrick Co., M. H., Chicago.
Girtanner Engrg. Corp., N. Y.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Stephens - Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., Chicago.

COOLERS, OIL
Griscom-Russell Co., New York.
Ross Heater & Mfg. Co., Buffalo.
Schutte & Koerting Co., Phila.

COOLING SYSTEMS
Binks Spray Equip. Co., Chicago.
Spray Engineering Co., Boston.
Sturtevant Co., B. F., Boston, Mass.
Wheeler Mfg. Co., C. H., Phila.
Yarnall-Waring Co., Phila.

COOLING TOWERS
Foster Wheeler Corp., New York.
Power Plant Equipment Co., Kansas City, Mo.
Wheeler Mfg. Co., C. H., Phila.

CORROSION PREVENTIVES
Dampney Co. of Am., Boston.

COUNTERS, REVOLUTION
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Lonergan Co., J. E., Phila., Pa.

COUPLINGS, COMPRESSION SHAFT
Nicholson & Co., W. H., Wilkes-Barre, Pa.

COUPLINGS, FLEXIBLE
Frederick Iron & Steel Co., Frederick, Md.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

COUPLINGS, UNION
Continental Valve & Equip. Co., Framingham, Mass.
Dart Mfg. Co., E. M., Providence, R. I.

CRUSHING AND GRINDING MACHINERY
Pennsylvania Crusher Co., Phila.

DEAERATORS
Elliott Co., Jeannette, Pa.
Ross Heater & Mfg. Co., Inc., Buffalo.

DESIGNERS & BUILDERS, POWER PLANT
Stone & Webster, Inc., Boston.

DOORS, AIR TIGHT
Brady Conveyors Corp., Chicago.

DRYERS, ROTARY
Fuller Lehigh Co., Fullerton, Pa.

DYNAMOS AND MOTORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Engberg's Elec. & Mech. Works. St. Joseph, Mich.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

ECONOMIZERS, FUEL.
Sturtevant Co., B. F., Boston,

EJECTORS
Elliott Co., Jeannette, Pa.
Penberthy Injector Co., Detroit.

ELECTRICAL SUPPLIES
Cutler-Hammer Mfg. Co., The, Milwaukee.
Ideal Commutator Dresser Co., Sycamore, Ill.

ELECTRICAL WIRES AND CABLES
American Steel & Wire Co., Chicago and New York.

ELEVATORS
Otis Elevator Co., New York

ELIMINATORS, AUTO, STEAM
Nicholson & Co., W. H., Wilkes-Barre, Pa.

ENGINE REPAIRS
Murray Iron Works Co., Burlington, Iowa.

ENGINE STOPS, AUTOMATIC
Locke Regulator Co., Salem, Mass.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

ENGINES, GAS AND GASOLINE
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Ingersoll-Rand Co., New York.
Sterling Eng. Co., Buffalo.
Worthington Pump & Mach. Corp., New York.

ENGINES, OIL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem.
Ingersoll-Rand Co., New York.
Sterling Eng. Co., Buffalo.
Worthington Pump & Mach. Corp., New York.

ENGINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
De Laval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Engberg's Elec. & Mech. Works. St. Joseph, Mich.
Erie Ball Engine Co., Pittsburgh
Erie City Iron Wks., Erie.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Boston, Mass.
Troy Eng. & Mach. Co., Troy, Pa.
Vilter Mfg. Co., Milwaukee, Wis.

EVAPORATORS
Foster Wheeler Corp., New York.
Ross Heater & Mfg. Co., Buffalo.

EVAPORATORS, WATER
Griscom-Russell Co., New York

EXHAUST HEADS
Burt Mfg. Co., The, Akron, O.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Swartwout Co., Cleveland.
Wright-Austin Co., Detroit.

EXHAUSTERS
Buffalo Forge Co., Buffalo.

EXPANDERS, TUBE
Nicholson & Co., W. H., Wilkes-Barre, Pa.

EXTRACTORS, OIL AND GREASE
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Patterson-Kelley Co., The, N. Y.

FANS, ELECTRIC
Buffalo Forge Co., Buffalo.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
Wing Mfg. Co., L. J., New York.

FANS, EXHAUST AND VENTILATING
Buffalo Forge Co., Buffalo.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
Prat-Daniel Corp., New York.
Sturtevant Co., B. F., Boston, Mass.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.

FAUCETS
Kennedy Valve Mfg. Co., Elmira.

FEED WATER FILTERS
Griscom-Russell Co., New York.
Permutit Co., Inc., New York.

FEED WATER HEATERS AND PURIFIERS
Bethlehem Steel Co., Bethlehem.
Cochrane Corp., Philadelphia.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York.
Hoppes Mfg. Co., Springfield, O.
Murray Iron Works Co., Burlington, Iowa.
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley Co., The, N. Y.
Ross Heater & Mfg. Co., Buffalo.
Schutte & Koerting Co., Phila.
Superheater Co., The, New York.
Swartwout Co., Cleveland.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

FEED WATER METERS
Atlantic Engrg. Co., New York

FEED WATER TREATMENTS
Chicago Chemical Co., Chicago.
Dearborn Chemical Co., Chicago.
Paige & Jones Chem. Co., Inc., New York.
Permutit Co., New York.

FILTERS, OIL
Bowser & Co., S. F., Fort Wayne.
Burt Mfg. Co., The, Akron, O.
Nugent & Co., Wm. W., Chicago.

FILTERS, WATER
Cochrane Corp., Philadelphia.
Paige & Jones Chem. Co., Inc., New York.
Permutit Co., New York.

FIRE BRICK
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Green Fire Brick Co., A. P., Mexico, Mo.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N.Y.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refrac. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., Inc., New York.

FIRE BRICK CEMENT
Botfield Refractories Co., Phila.
Insulating Products Corp., N. Y.
McLeod & Henry Co., Troy, N. Y.

FIRE CLAY
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Green Fire Brick Co., A. P., Mexico, Mo.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.

FIRE HYDRANTS
Howard Iron Works, Buffalo.

FITTINGS, FLANGE AND PIPE
Continental Valve & Equip. Co., Framingham, Mass.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Grinnell Co., Inc., Providence.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.
Walworth Co., Boston.

FITTINGS, AMMONIA
Vilter Mfg. Co., Milwaukee, Wis.

FITTINGS, COMPRESSION
Nugent & Co., Wm. W., Chicago.

FLANGES
Dart Mfg. Co., E. M., Providence, R. I.
Grinnell Co., Providence, R. I.
Kennedy Valve Mfg. Co., Elmira, N. Y.
Walworth Co., Boston.

FLOATS
Reliance Gauge Column Co., Cleveland.

FLOOR PLATES
Scully Steel & Iron Co., Chicago.

FLOORING, NON-SLIPPING
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

FLOORING, OPEN STEEL
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

FLOORING, STEEL
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

FLOORING, VENTILATING
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

FLOW METERS
Bailey Meter Co., Cleveland, O.
Brown Instrument Co., Phila.
Republic Flow Meters Co., Chicago.
Spray Engineering Co., Boston.

FLUE CLEANERS
Diamond Power Spec. Co., Detroit, Mich.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pierce Co., Wm. B., Buffalo.
Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.
Vulcan Soot Cleaner Co., Du Bois, Pa.

FLUE GAS ANALYSIS INSTRUMENTS
Permutit Co., New York.

FLUE SCRAPERS
Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.
Scully Steel & Iron Co., Chicago.

FURNACE BOTTOMS, CAST IRON, AIR-COOLED
Allen-Sherman-Hoff Co., Phila.

FURNACE CONSTRUCTION AND REPAIR
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.

FURNACE FIRE OBSERVERS
Springfield Boiler Co., Springfield, Ill.

FURNACE SURFACES, WATER COOLED.
Combustion Engrg. Corp., New York, N. Y.

FURNACE WALLS
Combustion Engrg. Corp., New York, N. Y.
Green Fire Brick Co., A. P., Mexico, Mo.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Superheater Co., New York.

FURNACES
Combustion Engrg. Corp., N. Y.
Erie City Iron Works, Erie, Pa.
Hofft Co., M. A., Indianapolis.

FURNACE SURFACES, WATER COOLED
Power Specialty Co., New York.
Superheater Co., New York.

GAS PRODUCERS
Wellman - Seaver - Morgan Co., The, Cleveland, O.

GASKETS
Crandall Pkg. Co., Palmyra, N.Y.
"Flexitallic" Gasket Co., Camden, N. J.
Garlock Pkg. Co., Palmyra, N.Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Johns-Manville Corp., New York.
Metallo Gasket Co., New Brunswick, N. J.
Quaker City Rubber Co., Phila.
Smooth-On Mfg. Co., Jersey City.

GASKETS, ASBESTOS, STEEL
"Flexitallic" Gasket Co., Camden, N. J.

GATES, ASH
Allen-Sherman-Hoff Co., Phila.

GAUGE COCKS
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Lonergan Co., J. E., Phila., Pa.
Penberthy Injector Co., Detroit.
Reliance Gauge Column Co., Cleveland.

GAUGE GLASSES
Jenkins Bros., New York, N. Y.

GAUGE TESTERS
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.

Corroded contact face —made tight with SMOOTH-ON NO. 1

DON'T get the idea that leakage can't be stopped where a flange contact face has become badly rusted, pitted, or dented. Regardless of whether the defect has been caused by rust, chemical erosion or battering, the depressions are easily built up to normal surface with Smooth-On No. 1, and the gasket will then hold tightly.

All that is necessary is to clean out the low spots thoroughly, tamp in a stiff putty of Smooth-On No. 1, scrape the surface true and give the Smooth-On time to harden.

The success of this procedure even under most unfavorable conditions was typically shown at an ice plant in New York, where the steam condenser shown in the picture developed a bad leak between a tube sheet and the shell. On disconnecting, the gasket face was found to be badly eaten away, and a tight joint could not be made with a rubber gasket, due to the imperfect face and edge of the casting.

The uneven places were filled with Smooth-On No. 1, and after letting the cement set, the gasket was replaced and tested. This joint has remained tight.

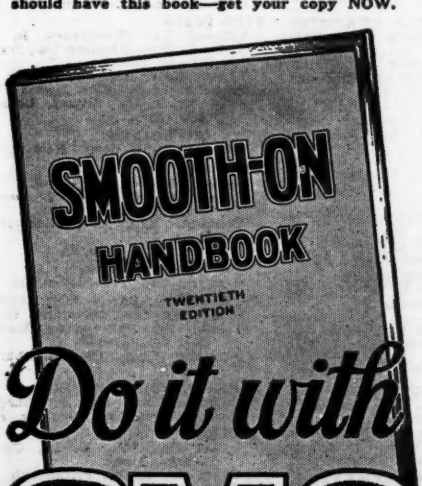
Smooth-On No. 1 used in this way becomes integral with the original metal, and stays put under any temperature and pressure, and is not impaired by gasket renewals.

This repair is one of the many that any Engineer can make by following the simple instructions in the Smooth-On Handbook.

Mail the coupon for your copy of the Handbook and get your Smooth-On No. 1 in 1 or 5-lb. can, or 25, 50 or 100-lb. keg from your nearest dealer, or if necessary direct from us.

THE SMOOTH-ON HANDBOOK FREE if you return the coupon

Twentieth Edition—Completely rewritten—136 pages of new data—193 diagrams, pictures and practical hints on at least 200 different uses for SMOOTH-ON. Every progressive engineer should have this book—get your copy NOW.



SMOOTH-ON MFG. CO.,
Dept. 31, 570 Communipaw Ave., Jersey City, N. J.

Please send copy of the SMOOTH-ON HANDBOOK, 20th Edition.

Name .....

Address .....

.....

-15-27

Do it with

SMOOTH-ON

Fisher Governor Co., Inc., The, Marshalltown, Iowa.

GAUGES, DIFFERENTIAL
Bailey Meter Co., Cleveland, O.

GAUGES, DRAFT
Bailey Meter Co., Cleveland, O.
Bristol Co., The, Waterbury.
Brown Instrument Co., Phila.
Huyette Co., Inc., The Paul B., Philadelphia.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago.

GAUGES, LIQUID LEVEL
Bristol Co., The, Waterbury.
Republic Flow Meters Co., Chicago.

GAUGES, PRESSURE AND RECORDING
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Bristol Co., The, Waterbury.
Lonergan Co., J. E., Phila., Pa.

GAUGES, WATER
Huyette Co., Inc., The Paul B., Philadelphia.
Lonergan Co., J. E., Phila., Pa.
Penberthy Injector Co., Detroit.
Reliance Gauge Column Co., Cleveland.

GEARS, DOUBLE HELICAL
De Laval Steam Turbine Co., Trenton, N. J.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GEARS, REDUCTION
De Laval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GENERATING SETS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Carling Turbine Blower Co., Worcester, Mass.
Elliott Co., Jeannette, Pa.
Engberg's Elec. & Mech. Works, St. Joseph, Mich.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GENERATORS, ELECTRIC
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Elliott Co., Jeannette, Pa.
Engberg's Elec. & Mech. Works, St. Joseph, Mich.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GOVERNORS, ENGINE
Pickering Governor Co., Portland, Conn.

GOVERNORS, PUMP
Atlas Valve Co., Newark, N. J.
Chaplin-Fulton Mfg. Co., The, Pittsburgh.
Continental Valve & Equip. Co., Framingham, Mass.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Gardner-Denver Co., The, Quincy, Ill.
Illinois Engrg. Co., Chicago.
Locke Regulator Co., Salem, Mass.
Mason Regulator Co., Boston.
Northern Equip. Co., Erie, Pa.
Pickering Governor Co., Portland, Conn.
Squires Co., C. E., Cleveland.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

GOVERNORS, STEAM ENGINE
Gardner-Denver Co., The, Quincy, Ill.

GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

GRATE BARS
Erie City Iron Wks., Erie.
Flynn & Emrich Co., Baltimore.

GRATES
Babcock & Wilcox Co., N. Y.
Flynn & Emrich Co., Baltimore.
Hofft Co., M. A., Indianapolis.
Kelly Foundry & Mach. Co., Goshen, Ind.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Murray Iron Works Co., Burlington, Iowa.
Neemes Fdry., Inc., Troy, N. Y.

GRATING, STEEL
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

GRATING, VENTILATION
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

GREASE
Cook's Sons, Inc., Adam, N. Y.
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Phila.
Standard Oil Co., (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Vacuum Oil Co., New York.

GREASE CUPS
(See Oil and Grease Cups.)

GUNS, REFRACTORY
Botfield Refractories Co., Phila.
Cement-Gun Co., Inc., Allentown, Pa.

HEAT EXCHANGERS
Foster Wheeler Corp., New York.
National Pipe Bending Co., New Haven, Conn.
Prat-Daniel Corp., New York.
Superheater Co., New York.
Vogt Mach. Co., Henry, Louisville, Ky.
Wheeler Mfg. Co., C. H., Phila.

HEATERS FOR SPECIAL PURPOSES
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
National Pipe Bending Co., New Haven, Conn.
Prat-Daniel Corp., New York.

HEATERS, HOT WATER
Griscom-Russell Co., New York.
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley, New York.
Powers Regulator Co., Chicago.
Ross Heater & Mfg. Co., Buffalo.

HEATERS, OIL
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley Co., New York.
Ross Heater & Mfg. Co., Buffalo.

HEATERS, STORAGE
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley Co., New York.

HEATING, DEVICES
Cutler-Hammer Mfg. Co., The, Milwaukee.

HOISTS
Sullivan Machy. Co., Chicago.

HOISTS, SKIP
Stephens-Adamson Mfg. Co., Aurora, Ill.

HOPPERS AND BINS, COAL AND ASH
Allen-Sherman-Hoff Co., Phila.
Brady Conveyors Corp., Chicago.
Combustion Engrg. Corp., New York.
Connery & Co., Inc., Phila.
Frederick Iron & Steel Co., Frederick, Md.

HOSE
Crandall Pkg., Palmyra, N. Y.
Quaker City Rubber Co., Phila.

HYDROMETERS
Taylor Inst. Co., Rochester, N. Y.

HYGRODIEKS
Taylor Inst. Co., Rochester, N. Y.

ICE MAKING AND REFRIGERATING MACHINERY
Ingersoll-Rand Co., New York.
Vilter Mfg. Co., Milwaukee, Wis.
Vogt Mach. Co., Henry, Louisville, Ky.

INDICATORS, ENGINE
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.

INJECTORS AND INSPIRATORS
Penberthy Injector Co., Detroit.
Schutte & Koerting Co., Phila.
Superheater Co., The, New York.

INSTRUMENTS, ELECTRICAL
Weston Elec. Inst. Corp., Newark.

INSTRUMENTS, RECORDING
Permutit Co., New York.
Weston Elec. Inst. Corp., Newark.
Simplex Valve & Meter Co., Philadelphia.

INSULATING MATERIAL
Cutler-Hammer Mfg. Co., The, Milwaukee.
Insulating Products Corp., N. Y.
Johns-Manville Corp., New York.
Quigley Furnace Specialties Co., Inc., New York.

JOINTS, EXPANSION
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York.
Howard Iron Works, Buffalo.
Ross Heater & Mfg. Co., Buffalo.
Wheeler Mfg. Co., C. H., Phila.

LADDER STEPS, STEEL
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

LINING, FURNACE
Norton Co., Worcester, Mass.

LOADERS AND UNLOADERS
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago, Ill.

LUBRICANTS
Cook's Sons, Inc., Adam, N. Y.
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Phila.
Standard Oil Co. (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Vacuum Oil Co., New York.

LUBRICATORS
Bowser & Co., S. F., Ft. Wayne.
Cook's Sons, Inc., Adam, N. Y.
Greene, Tweed & Co., New York.
Hills-McCanna Co., Chicago, Ill.
Keystone Lubricating Co., Phila.
Lunkenheimer Co., Cincinnati.
Manzel Bros. Co., Buffalo, N. Y.
Nugent & Co., Wm. W., Chicago.
Powell Co., Wm., Cincinnati.
Stephenson Mfg. Co., Albany.
Williams Valve Co., D. T., Cincinnati, Ohio.

LUBRICATORS, FORCED FEED
Greene, Tweed & Co., N. Y.
Hills-McCanna Co., Chicago, Ill.
Manzel Bros. Co., Buffalo, N. Y.

MECHANICAL DRAFT APPARATUS
Buffalo Forge Co., Buffalo.
Coppus Engrg. Corp., Worcester.
Prat-Daniel Corp., New York.
Sturtevant Co., B. F., Boston, Mass.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

METERS, AIR AND GAS
Bailey Meter Co., Cleveland, O.
Republic Flow Meters Co., Chicago.

METERS, BOILER
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Philadelphia.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.
Yarnall-Waring Co., Phila.

METERS, COAL
Bailey Meter Co., Cleveland, O.
C. J. Mfg. Co., Philadelphia.
Republic Flow Meters Co., Chicago.

METERS, FEED WATER
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.
Worthington Pump & Mach. Corp., New York.

METERS, STEAM
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Philadelphia.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.

METERS, WATER
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.

MOND "SEVENTY" METAL
American Mond Nickel Co., Pittsburgh

NOZZLES FOR ALL PURPOSES
Binks Spray Equip. Co., Chicago, Ill.
Schutte & Koerting Co., Phila.
Spray Engineering Co., Boston.

OIL AND GREASE CUPS
Cook's Sons, Inc., Adam, N. Y.
Keystone Lubricating Co., Phila.
Lonergan Co., J. E., Phila., Pa.
Lunkenheimer Co., Cincinnati.
Penberthy Injector Co., Detroit.
Powell Co., Wm., Cincinnati.
Williams Valve Co., D. T., Cincinnati, Ohio.

OIL BURNING EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Schutte & Koerting Co., Phila.

OIL CIRCUIT BREAKERS
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

OIL PURIFIERS
Bowser & Co., S. F., Fort Wayne.
De Laval Steam Turbine Co., Trenton, N. J.
Nugent & Co., Wm. W., Chicago.

OIL SEPARATORS
Atlantic Engrg. Co., New York
Elliott Co., Jeannette, Pa.
Griscom-Russell Co., New York.
Nugent & Co., Wm. W., Chicago.
Wright-Austin Co., Detroit.

OIL STORAGE EQUIPMENT
Bowser & Co., S. F., Fort Wayne.

OIL TANKS
Bowser & Co., S. F., Fort Wayne.
Manzel Bros. Co., Buffalo, N. Y.
Nugent & Co., Wm. W., Chicago.

OILING SYSTEMS
Bowser & Co., S. F., Fort Wayne.
Burt Mfg. Co., The, Akron, O.
Hills-McCanna Co., Chicago, Ill.
Nugent & Co., Wm. W., Chicago.

OILS, LUBRICATING
Cook's Sons, Inc., Adam, N. Y.
Dearborn Chemical Co., Chicago.
Standard Oil Co., (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Vacuum Oil Co., New York.

PACKING, ASBESTOS
Crandall Pkg. Co., Palmyra, N. Y.
Garlock Pkg. Co., Palmyra, N. Y.

PACKING CENTRIFUGAL PUMP
Conneaut Pkg. Co., Conneaut, O.
Garlock Pkg. Co., Palmyra, N. Y.
Metalastic Inc., Jersey City, N. J.

PACKING, FLAX
Crandall Pkg. Co., Palmyra, N. Y.
Garlock Pkg. Co., Palmyra, N. Y.

PACKING, METALLIC
Conneaut Pkg. Co., Conneaut, O.
Crandall Pkg. Co., Palmyra, N. Y.
Crane Packing Co., Chicago, Ill.
Garlock Pkg. Co., Palmyra, N. Y.
Holmes Metallic Packing Co., Wilkes-Barre, Pa.
Metalastic Inc., Jersey City, N. J.

PACKING, METALLIC FOR CONDENSER TUBES
Crane Packing Co., Chicago, Ill.

PACKING, PISTON AND ROD
Conneaut Pkg. Co., Conneaut, O.
Crandall Pkg. Co., Palmyra, N. Y.
Crane Packing Co., Chicago, Ill.
Garlock Pkg. Co., Palmyra, N. Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Greene, Tweed & Co., N. Y.
Johns-Manville Corp., N. Y.
Metalastic Inc., Jersey City, N. J.
Quaker City Rubber Co., Phila.

PACKING, SHEET
Crandall Pkg. Co., Palmyra, N. Y.
Garlock Pkg. Co., Palmyra, N. Y.
Goetze Gasket & Packing Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.
Johns-Manville Corp., N. Y.
Quaker City Rubber Co., Phila.

PACKING, VALVE STEM
Conneaut Pkg. Co., Conneaut, O.
Garlock Pkg. Co., Palmyra, N. Y.
Johns-Manville Corp., N. Y.
Metalastic Inc., Jersey City, N. J.
Quaker City Rubber Co., Phila.

PAINT, ANTI-CORROSIVE
Dampney Co. of Am., Boston.

PAINT, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

PAINT, HEAT RESISTING
Dampney Co. of Am., Boston.

PAINT, METAL
Dampney Co. of Am., Boston.

PAINT, STEEL PRESERVATIVE
Dampney Co. of Am., Boston.

PIPE BENDING
Grinnell Co., Providence, R. I.
National Pipe Bending Co., New Haven, Conn.
National Valve & Mfg. Co., Pittsburgh.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Walworth Co., Boston.

PIPE CLAMPS, COUPLINGS AND JOINTS
Grinnell Co., Providence, R. I.

PIPE COILS
Grinnell Co., Providence, R. I.
National Pipe Bending Co., New Haven, Conn.
Power Piping Co., Pittsburgh.
Superheater Co., The, New York.
Vogt Mach. Co., Henry, Louisville, Ky.

PIPE COVERINGS
Johns-Manville Corp., New York.

PIPE CUTTERS
Oster Mfg. Co., Cleveland.
Toledo Pipe Threading Mach. Co., The, Toledo, O.
Trimont Mfg. Co., Roxbury, Mass.
Walworth Co., Boston.

PIPE FABRICATORS
Grinnell Co., Providence, R. I.

PIPE THREADING MACHINES
Oster Mfg. Co., Cleveland, O.
Toledo Pipe Threading Mach. Co., The, Toledo, O.
Trimont Mfg. Co., Roxbury, Mass.

PIPE, WROUGHT STEEL
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.

PIPING
Baker Co., Inc., R. H., Cambridge, Mass.
Byers Co., A. M., Pittsburgh.
Connery & Co., Inc., Phila.
National Tube Co., Pittsburgh.
National Valve & Mfg. Co., Pittsburgh.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Power Piping Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Walworth Co., Boston.

PIPING CONTRACTING MANUFACTURERS
Baker Co., Inc., R. H., Cambridge, Mass.
Byers Co., A. M., Pittsburgh.
Grinnell Co., Providence, R. I.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.

Refining and its relation to effective TURBINE lubrication

The two essential problems involved in the lubrication of the steam turbine are:

1. Cessation or impairment of lubrication.
2. Variations in rate of heat attractions.

The reason for this is that the oil ways and oil piping will tend to become clogged or obstructed by sludge or emulsified matter.

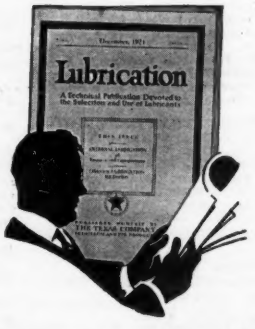
Now a turbine oil, in order to overcome these conditions as effectively as possible, must be able to prevent:—

(a) **The oxidizing and acid-forming effects of heat and air.**

(b) **Emulsification with water.**

(c) **Development of sludges from such emulsification due to the presence of dust and dirt, and**

(d) **The catalyzing effects which metallic particles (especially copper and brass) involve in the formation of sludges.**



The February 1925 issue of our magazine "Lubrication" contains a comprehensive treatment of the subject of Steam Turbine lubrication. Included is a list of steam stations (by name of maker) with complete TEXACO recommendations for correct lubrication.

Write to the address below for a free copy (specifying the issue)—and ask to be put on the free list to receive "Lubrication" monthly.

The effects of these detriments will be most satisfactorily retarded by the use of the lubricant which is most *highly refined.*

Such lubricants are:

TEXACO
REGAL OILS

—the most highly refined turbine oils on the market today.

They are thoroughly refined, step by step, to remove every possible trace of emulsion-forming impurities, and will do their work admirably under the most unusual conditions.

TEXACO REGAL OILS for turbine lubrication are obtainable in four distinct ranges of Saybolt viscosity at 100° Fahr. as follows:

TEXACO REGAL OIL "A"	-	**145 Seconds**
TEXACO REGAL OIL "B"	-	**180 Seconds**
TEXACO REGAL OIL "C"	-	**300 Seconds**
TEXACO REGAL OIL "E"	-	**500 Seconds**

We shall be glad to demonstrate the splendid lubricating and wear-reducing qualities of TEXACO REGAL OILS on any of your Turbine equipment, any time—and will cooperate with you in determining the most economical amount of oil to apply to obtain the greatest efficiency.

THE TEXAS COMPANY

Texaco Petroleum Products

DEPT. QD 17 BATTERY PLACE, NEW YORK CITY

OFFICES IN PRINCIPAL CITIES

Power Piping Co., Pittsburgh.
Pope, Wm. A., Chicago.

PIPE HANGERS & SUPPLIES
Grinnell Co., Providence, R. I.

PLANIMETERS
Robertson & Sons, Jas. L., N. Y.

PLATE STEEL CONSTRUCTION
Littleford Bros., Cincinnati.

PORTABLE CONVEYORS
Jeffrey Mfg. Co., Columbus, O.

POWER PLANT MANAGEMENT
Stone & Webster, Inc., Boston.

POWER SHOWS
Midwestern Engrg. Exposition Co., Inc., Chicago

POWER TRANSMITTING MACHINERY
Webster Mfg. Co., Chicago.

PREHEATER AND HEAT EXCHANGERS
Patterson-Kelley Co., New York.
Prat-Daniel Corp., New York.

PROTECTIVE COATINGS
Dampney Co. of Am. Boston.

PULLEY, FRICTION CLUTCH
Link-Belt Co., Chicago, Ill.

PULVERIZED FUEL EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., New York, N. Y.
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa.

PULVERIZERS, COAL
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., The, Columbus.
Pennsylvania Crusher Co., Phila.
Strong-Scott Mfg. Co., Minneapolis, Minn.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.

PULVERIZERS, LIMESTONE
Pennsylvania Crusher Co., Phila.

PUMPING SYSTEMS, AIR LIFT
Sullivan Machy. Co., Chicago.
Ingersoll-Rand Co., New York.

PUMPS, BOILER FEED
American Steam Pump Co., Battle Creek, Mich.
Bethlehem Steel Co., Bethlehem.
Buffalo Steam Pump Co., Buffalo, N. Y.
Cameron Steam Pump Wks., A. S. (Ingersoll-Rand Co.), New York.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Gardner-Denver Co., The, Quincy, Ill.
Ingersoll-Rand Co. (Cameron Steam Pump Wks., A. S.), New York.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.
Worthington Pump & Machy. Corp., New York,

PUMPS, CENTRIFUGAL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
Cameron Steam Pump Wks., A. S. (Ingersoll-Rand Co.), New York.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Ingersoll-Rand Co. (Cameron Steam Pump Wks., A. S.), New York.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Northern Equipment Co., Erie.
Platt Iron Works, Dayton, O.
Terry Steam Turbine Co., Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.
Yeomans Bros. Co., Chicago, Ill.

PUMPS, DEEP WELL
American Steam Pump Co., Battle Creek, Mich.
Lecourtenay Co., Newark, N. J.
Northern Equipment Co., Erie.
Platt Iron Works, Dayton, O.
Worthington Pump & Mach. Corp., New York.

PUMPS, ELECTRIC
American Steam Pump Co., Battle Creek, Mich.
Gardner-Denver Co., The, Quincy, Ill.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.
Yeomans Bros. Co., Chicago, Ill.

PUMPS, ELEVATOR AND FIRE
American Steam Pump Co., Battle Creek, Mich.
De Laval Steam Turbine Co., Trenton, N. J.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Warren Steam Pump Co., Inc., Warren, Mass.
Yeomans Bros. Co., Chicago.

PUMPS, GENERAL SERVICE
Bethlehem Steel Co., Bethlehem.
Buffalo Steam Pump Co., Buffalo, N. Y.
Platt Iron Wks., Dayton, O.
Yeomans Bros. Co., Chicago, Ill.

PUMPS HYDRAULIC PRESSURE
American Steam Pump Co., Battle Creek, Mich.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.

PUMPS, JET
Manistee Iron Works, Manistee.
Wheeler Mfg. Co., C. H., Phila.

PUMPS, OIL
Gardner-Denver Co., The, Quincy,
Lonergan Co., J. E., Phila., Pa.
Lunkenheimer Co., Cincinnati.
Manzel Bros. Co., Buffalo, N. Y.
Nugent & Co., Wm. W., Chicago.
Penberthy Injector Co., Detroit.
Warren Steam Pump Co., Inc., Warren, Mass.

PUMPS, POWER
American Steam Pump Co., Battle Creek, Mich.
Gardner-Denver Co., The, Quincy, Ill.
Lecourtenay Co., Newark, N. J.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.
Worthington Pump & Mach. Corp., New York.

PUMPS, ROTARY
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Platt Iron Works, Dayton, O.

PUMPS, SEWAGE
Yeomans Bros. Co., Chicago, Ill.

PUMPS, STEAM
Platt Iron Works, Dayton, O.

PUMPS, TURBINE
Moore Steam Turbine Corp., Wellsville, N. Y.

PUMPS, VACUUM
American Steam Pump Co., Battle Creek, Mich.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Gardner-Denver Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Sullivan Machy. Co., Chicago.
Warren Steam Pump Co., Inc., Warren, Mass.
Wheeler Mfg. Co., C. H., Phila.

PUMPS, WATERWORKS
Allis-Chalmers Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
Bethlehem Steel Co., Bethlehem.
Gardner-Denver Co., The, Quincy, Ill.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Platt Iron Works, Dayton, O.
Terry Steam Turbine Co., Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.

PURIFIERS, BOILER FEED
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Permutit Co., New York.

PYROMETERS
Bristol Co., The, Waterbury.
Brown Inst. Co. Phila., Pa.
Leeds & Northrup Co., Phila.
Republic Flow Meters Co., Chicago, Ill.
Superheater Co., The, N. Y.
Taylor Inst. Co., Rochester, N. Y.

QUENCHERS, ASH
Allen-Sherman-Hoff Co., The, Philadelphia, Pa

RECORDERS, LIQUID LEVEL
Bristol Co., The, Waterbury.

RECORDING INSTRUMENTS
Bristol Co., The, Waterbury.
Leeds & Northrup Co., Phila.
Taylor Inst. Co., Rochester, N. Y.

REFRACTORIES
Botfield Refractories Co., Phila.
Harbison-Walker Refract. Co., Pittsburgh.
Insulating Products Corp., N. Y.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Rust Engrg. Co., Pittsburgh.

REGULATORS, DAMPER
Atlas Valve Co., Newark, N. J.
Brown Inst. Co., Philadelphia.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Locke Regulator Co., Salem, Mass.
Mason Regulator Co., Boston.
National Regulator Co., Chicago.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Wing Mfg. Co., L. J., New York.

REGULATORS, FAN ENGINE
Atlas Valve Co., Newark, N. J.

REGULATORS, FEED WATER
Atlas Valve Co., Newark, N. J.
Chaplin-Fulton Mfg. Co., Pittsburgh.
Northern Equipment Co., Erie.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York.
Squires Co., C. E., Cleveland.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.
Wright-Austin Co., Detroit.

REGULATORS, PRESSURE
Boylston St'm Spec. Co., Chicago.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Locke Regulator Co., Salem, Mass.
Mason Regulator Co., Boston.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.
Squires Co., C. E., Cleveland.
Strong Carlisle & Hammond Co., Cleveland, Ohio.

REGULATORS, TEMPERATURE
Atlas Valve Co., Newark, N. J.
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.
Taylor Inst. Co., Rochester, N. Y.

REGULATORS, VOLTAGE
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

ROPE DRESSING AND PRESERVATIVE
Stephenson Mfg. Co., Albany

ROPE, WIRE
American Steel & Wire Co., Chicago and New York.

RUST PREVENTIVES
Dearborn Chem. Co., Chicago.

SCALE REMOVERS (Mechanical)
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

SCALES, COAL.
Richardson Scale Co., Clifton, N. J.

SCREENS
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.

SEAL RINGS
Cook's Seal Ring, Chicago, Ill.

SEPARATORS AND EXTRACTORS, STEAM AND OIL
Cochrane Corp., Philadelphia.
Direct Separator Co., Syracuse.
Gardner-Denver Co., The, Quincy, Ill.
Hoppes Mfg. Co., Springfield, O.
Illinois Engrg. Co., Chicago.
Murray Iron Works Co., Burlington, Iowa.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Robertson & Sons, J. L., N. Y.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Swartwout Co., Cleveland.
Williams Valve Co., D. T., Cincinnati, Ohio.
Wright-Austin Co., Detroit.

SEPARATORS, STEAM AND AIR
Griscom-Russell Co., New York.
Nicholson & Co, W. H., Wilkes-Barre, Pa.

SEWAGE EJECTORS
Yeomans Bros. Co., Chicago, Ill.

SHAFTING
National Tube Co., Pittsburgh.

SLUICING SYSTEMS, ASH
Allen-Sherman-Hoff Co., Phila.

SMOKE FLUES
Littleford Bros., Cincinnati.

SODIUM ALUMINATE
Chicago Chemical Co., Chicago.

SOOT BLOWERS
Diamond Power Spec. Corp., Detroit, Mich.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.

SPRAY AIR WASHERS
Binks Spray Equip. Co., Chicago.
Spray Engineering Co., Boston.

SPRAY COOLING SYSTEMS
Binks Spray Equip. Co., Chicago.
Buffalo Forge Co., Buffalo.
Power Plant Equipment Co., Kansas City, Mo.
Spray Engineering Co., Boston.

SPRAY NOZZLES
Connor Co., Inc., The W. B., N. Y.

SPROCKET RIMS
Babbitt Steam Specialty Co., New Bedford, Mass.

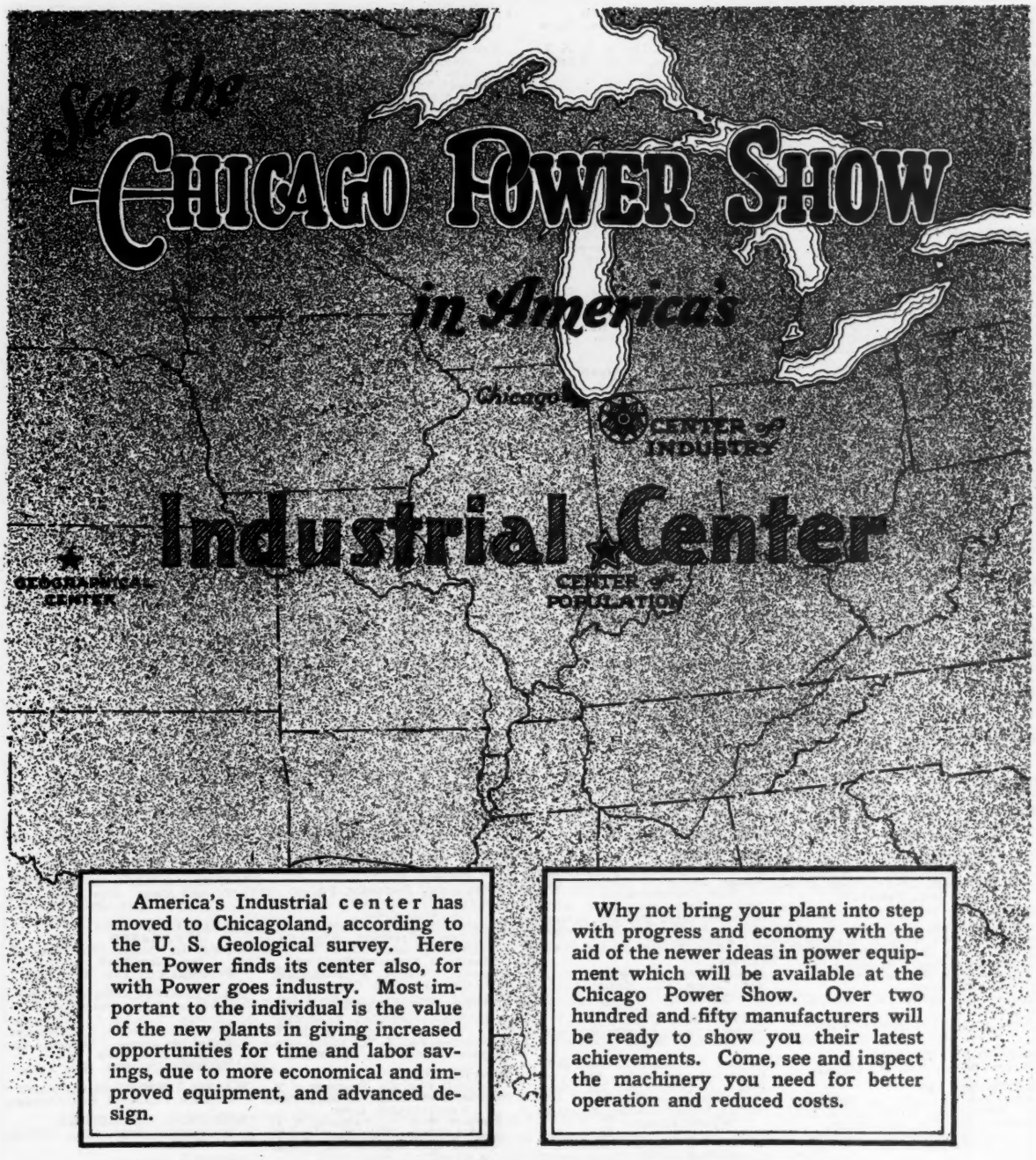
STACKS, METAL
Connery & Co., Inc., Phila.
Erie City Iron Wks., Erie.
Littleford Bros., Cincinnati.
Prat-Daniel Corp., New York.
Vogt Mach. Co., Henry, Louisville, Ky.

STAIR TREAD, ANTI-SLIP
Irving Iron Works Co., Long Island City, N. Y.
Scully Steel & Iron Co., Chicago.
Tri-Lok Co., Pittsburgh.

STEAM PURIFIERS
Atlantic Engrg. Co., New York

STEAM TRAPS
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Armstrong Machine Wks., Three Rivers, Mich.
Atlantic Engrg. Co., New York
Bolyston St'm Spec. Co., Chicago.
Bundy Steam Trap Co., Nashua.
Cochrane Corp., Philadelphia.
Connor Co., Inc., The W. B., N. Y.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Golden-Anderson Valve Specialty Co., Pittsburgh.
Illinois Engrg Co., Chicago.
Johns-Manville Corp., N. Y.
Locke Regulator Co., Salem, Mass.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Patterson-Kelley, New York.
Powers Regulator Co., Chicago.
Reliance Gauge Column Co., Cleveland.
Sarco Company, Inc., New York.
Squires Co., C. E., Cleveland.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Swartwout Co., Cleveland.
Williams Valve Co., D. T., Cincinnati, Ohio.
Wright-Austin Co., Detroit.
Yarnall-Waring Co., Phila.

STEAM TURBINES—POWER
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Carling Turbine Blower Co., Worcester, Mass.
DeLaval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Co., Wellsville, N. Y.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wing Mfg. Co., L. J., New York.



America's Industrial center has moved to Chicagoland, according to the U. S. Geological survey. Here then Power finds its center also, for with Power goes industry. Most important to the individual is the value of the new plants in giving increased opportunities for time and labor savings, due to more economical and improved equipment, and advanced design.

Why not bring your plant into step with progress and economy with the aid of the newer ideas in power equipment which will be available at the Chicago Power Show. Over two hundred and fifty manufacturers will be ready to show you their latest achievements. Come, see and inspect the machinery you need for better operation and reduced costs.

MIDWESTERN ENGINEERING EXPOSITION
53 W. JACKSON BLVD., CHICAGO

Meet with the Masters of Power at the

Chicago Power Show

Coliseum February 14th to 18th

STOCKS AND DIES
Oster Mfg. Co., Cleveland.
Toledo Pipe Threading Mach. Co., The, Toledo, O.

STOKERS, CHAIN GRATE
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Laclede Stoker Co., St. Louis.

STOKERS, FORCED DRAFT
Flynn & Emrich Co., Baltimore.

STOKERS, HAND OPERATED
Flynn & Emrich Co., Baltimore.
Hofft Co., M. A., Indianapolis.
Kelly Foundry & Mach. Co., The, Goshen, Ind.
Marion Mach. Fdry. & Supply Co., Marion, Ind.

STOKERS, HOPPER FED
Flynn & Emrich Co., Baltimore.

STOKERS, MECHANICAL
American Engrg. Co., Phila.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
Hofft Co., M. A., Indianapolis.
Sturtevant Co., B. F., Boston, Mass.

STOKERS, OVERFEED AND UNDERFEED
Combustion Engrg. Corp., N. Y.
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
Laclede Stoker Co., St. Louis.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

STRAINERS
Davis Regulator Co., G. M., Chicago.
Ross Heater & Mfg. Co., Buffalo.
Sarco Co., Inc., New York.
Spray Engineering Co., Boston.
Wright-Austin Co., Detroit.

STRAINERS, OIL
Elliott Co., Jeannette, Pa.
Griscom-Russell Co., New York.
Ross Heater & Mfg. Co., Buffalo.
Sarco Co., Inc., New York.

SUPERHEATERS, STEAM
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Power Plant Equipment Co., Kansas City, Mo.
Superheater Co., The, New York.

SWITCHBOARDS
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

SWITCHBOARDS, ASBESTOS
Johns-Manville Corp., N. Y.

SWITCHES
Cutler-Hammer Mfg. Co., The, Milwaukee.

TACHOMETERS
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Bristol Co., The, Waterbury.

TANKS
Connery & Co., Inc., Phila.
Erie City Iron Wks., Erie.
Heine Boiler Co., St. Louis, Mo.
Littleford Bros., Cincinnati, O.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Vogt Mach. Co., Henry, Louisville, Ky.

TELESCOPIC OILERS
Nugent & Co., Wm. W., Chicago.

THERMOMETERS
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Bristol Co., The, Waterbury.
National Regulator Co., Chicago.
Powers Regulator Co., Chicago.
Taylor Inst. Co., Rochester, N. Y.

THERMOMETERS, RECORDING AND INDICATING
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Bristol Co., The, Waterbury.
Brown Instrument Co., Phila.
Leeds & Northrup Co., Phila.
Taylor Inst. Co., Rochester, N. Y.

TOOLS AND SUPPLIES
Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.
Trimont Mfg. Co., Roxbury, Mass.

TRAMWAYS
American Steel & Wire Co., Chicago and New York.

TRANSFORMERS AND CONDENSERS
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

TRANSMISSION ROPE
American Steel & Wire Co., Chicago and New York.

TRAPS, COMPRESSED AIR
Armstrong Machine Wks., Three Rivers, Mich.
Connor Co., Inc., The W. B., N. Y.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

TRAPS, RADIATOR
Armstrong Machine Wks., Three Rivers, Mich.
Sarco Co., Inc., New York.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

TRAPS, RETURN
Bundy Steam Trap Co., Nashua.
Sarco Co., Inc., New York.

TRAPS, STEAM AND RADIATOR
Connor Co., Inc., The W. B., N. Y.
Illinois Engrg. Co., Chicago.
Sarco Co., Inc., New York.

TRAPS, VACUUM
Armstrong Machine Wks., Three Rivers, Mich.
Bundy Steam Trap Co., Nashua.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

TRAVELING CRANES
Wellman - Seaver - Morgan Co., The, Cleveland, O.

TUBE COATINGS
Dampney Co. of Am., Boston.

TUBE CUTTERS
Lagonda Mfg. Co., Springfield, O.
Scully Steel & Iron Co., Chicago.

TUBING
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Byers Co., A. M., Pittsburgh.
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

TUBING, CONDENSER
Foster Wheeler Corp., New York.

TUBING, SEAMLESS STEEL
National Tube Co., Pittsburgh.

TURBINES, HYDRAULIC
De Laval Steam Turbine Co., Trenton, N. J.

TURBO GENERATORS
Elliott Co., Jeannette, Pa.

UNDERGROUND HEATING SYSTEM
Baker Co., Inc., R. H., Cambridge, Mass.
Johns-Manville Corp., N. Y.

UNIONS
Atlas Valve Co., Newark, N. J.
Continental Valve & Equip. Co., Framingham, Mass.
Dart Mfg. Co., E. M., Providence, R. I.
Walworth Co., Boston.

VALVE DISCS
Garlock Pkg. Co., Palmyra, N. Y.
Goetze Gasket & Packing Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira.
Metallo Gasket Co., New Brunswick, N. J.

VALVES
Atlas Valve Co., Newark, N. J.
Vogt Mach. Co., Henry, Louisville, Ky.

VALVES, ALTITUDE
Golden-Anderson Valve Specialty Co., Pittsburgh.

VALVES, AUTOMATIC CUT-OFF
Elliott Co., Jeannette, Pa.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Golden-Anderson Valve Specialty Co., Pittsburgh.

VALVES, AUTOMATIC STOP AND CHECK
Davis Regulator Co., G. M., Chicago, Ill.
Golden-Anderson Valve Specialty Co., Pittsburgh.
Illinois Engrg. Co., Chicago.
Locke Regulator Co., Salem, Mass.
Ruggles-Klingemann Mfg. Co., Salem, Mass.

VALVES, BLOW-OFF
Elliott Company, Jeannette, Pa.
Homestead Valve Mfg. Co., Homestead, Pa.
Jenkins Bros., New York, N. Y.
Lunkenheimer Co., Cincinnati, O.
Powell Co., Wm., Cincinnati, O.
Scully Steel & Iron Co., Chicago.
Yarnall-Waring Co., Phila.

VALVES, BY-PASS
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira.
Mason Regulator Co., Boston.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Powell Co., Wm., Cincinnati, O.
Scully Steel & Iron Co., Chicago.

VALVES, CHECK
Golden-Anderson Valve Specialty Co., Pittsburgh.
Homestead Valve Mfg. Co., Homestead, Pa.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira.
Locke Regulator Co., Salem.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Powell Co., Wm., Cincinnati, O.
Schutte & Koerting Co., Phila.
Walworth Co., Boston.
Williams Valve Co., The D. T., Cincinnati, Ohio.

VALVES, FLOAT
Atlas Valve Co., Newark, N. J.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Mason Regulator Co., Boston.

VALVES, GATE
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira.
Lunkenheimer Co., Cincinnati.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Powell Co., Wm., Cincinnati, O.
Vogt Mach. Co., Henry, Louisville, Ky.
Walworth Co., Boston.
Williams Valve Co., D. T., Cincinnati, Ohio.

VALVES, GLOBE
Homestead Valve Mfg. Co., Homestead, Pa.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., Elmira.
Locke Regulator Co., Salem.
Lunkenheimer Co., Cincinnati.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Powell Co., Wm., Cincinnati, O.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Vogt Mach. Co., Henry, Louisville, Ky.
Walworth Co., Boston.
Williams Valve Co., D. T., Cincinnati, Ohio.

VALVES, HYDRAULIC
Homestead Valve Mfg. Co., Homestead, Pa.
Kennedy Valve Mfg. Co., Elmira.
Williams Valve Co., D. T., Cincinnati, Ohio.
Vogt Mach. Co., Henry, Louisville, Ky.
Yarnall-Waring Co., Phila.

VALVES, NON-RETURN
Davis Regulator Co., G. M., Chicago, Ill.
Elliott Co., Jeannette, Pa.
Golden-Anderson Valve Specialty Co., Pittsburgh.
Illinois Engrg. Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Schutte & Koerting Co., Phila.
Strong, Carlisle & Hammond, Co., Cleveland, Ohio.

VALVES, POP SAFETY
American Schaeffer & Budenberg Corp., Brooklyn, N. Y.
Lonergan Co., J. E., Phila., Pa.
Lunkenheimer Co., Cincinnati.

VALVES, PUMP
Crandall Pkg. Co., Palmyra, N.Y.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Garlock Pkg. Co., Palmyra, N. Y.
Jenkins Bros., New York, N. Y.
Quaker City Rubber Co., Phila.

VALVES, RADIATOR
Jenkins Bros., New York, N. Y.
Powell Co., Wm., Cincinnati, O.
Sarco Co., Inc., New York.

VALVES, REDUCING
Atlas Valves Co., Newark, N. J.
Chaplin-Fulton Mfg. Co., Pittsburgh, Pa.
Continental Valve & Equip. Co., Framingham, Mass.
Davis Regulator Co., G. M., Chicago, Ill.
Elliott Company, Jeannette, Pa.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Golden-Anderson Valve Specialty Co., Pittsburgh.
Illinois Engrg. Co., Chicago.
Locke Regulator Co., Salem.
Mason Regulator Co., Boston.
National Regulator Co., Chicago.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Squires Co., C. E., Cleveland, O.

VALVES, REGRINDING
Homestead Valve Mfg. Co., Homestead, Pa.
Mason Regulator Co., Boston.
Penberthy Injector Co., Detroit.
Williams Valve Co., D. T., Cincinnati, Ohio.

VALVES, REGULATING
Atlas Valve Co., Newark, N. J.
Davis Regulator Co., G. M., Chicago.
Golden-Anderson Valve Specialty Co., Pittsburgh.
Powers Regulator Co., Chicago.
Swartwout Co., Cleveland.

VALVES, RELIEF
Cochrane Corp., Philadelphia.
Davis Regulator Co., G. M., Chicago.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Golden-Anderson Valve Specialty Co., Pittsburgh.
Illinois Engrg. Co., Chicago.
Locke Regulator Co., Salem, Mass.
Lonergan Co., J. E., Phila., Pa.
Mason Regulator Co., Boston.

VALVES, RUBBER
Garlock Pkg. Co., Palmyra, N. Y.
Quaker City Rubber Co., Phila.

VALVES, SIGHT FEED
Nugent & Co., Wm. W., Chicago.

VALVES, STEEL
Lunkenheimer Co., Cincinnati.

VALVES, STOP
Golden-Anderson Valve Specialty Co., Pittsburgh.
Homestead Valve Mfg. Co., Homestead, Pa.
Schutte & Koerting Co., Phila.

VALVES, STOP AND CHECK
Golden-Anderson Valve Specialty Co., Pittsburgh.

VALVES, THREE AND FOUR WAY
Nicholson & Co., W. H., Wilkes-Barre, Pa.

VENTILATING APPARATUS
Buffalo Forge Co., Buffalo.
Burt Mfg. Co., The, Akron, O.
Coppus Engrg. Corp., Worcester.
Sturtevant Co., B. F., Boston, Mass.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.

WALKWAYS, OPEN STEEL
Irving Iron Works Co., Long Island City, N. Y.
Tri-Lok Co., Pittsburgh.

WATER COLUMNS AND ALARMS
Reliance Gauge Column Co., The, Cleveland, O.
Wright-Austin Co., Detroit.

WATER COOLING EQUIPMENT
Power Plant Equipment Co., Kansas City, Mo.

WATER PURIFYING APPARATUS
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., The, New York.

WATER SOFTENING SYSTEMS
Cochrane Corp., Philadelphia.
Chicago Chemical Co., Chicago.
Dearborn Chemical Co., Chicago.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., The, New York.

WATER TESTING EQUIPMENT
Chicago Chemical Co., Chicago.

WEIGHING MACHINERY.
Richardson Scale Co., Clifton, N. J.

WEIGH LARRIES
Brady Conveyors Corp., Chicago.
Richardson Scale Co., Clifton, N. J.
Stephens - Adamson Mfg. Co., Aurora, Ill.

WELDED HEADERS
Grinnell Co. Providence, R. I.

WHISTLES
Lonergan Co., J. E., Phila., Pa.
Powell Co., Wm., Cincinnati, O.

WIRE BRUSHES
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

WIRE OF EVERY DESCRIPTION
American Steel & Wire Co., Chicago and New York.

WIRE ROPE AND FITTINGS
American Steel & Wire Co., Chicago and New York.

WRENCHES
Trimont Mfg. Co., Roxbury, Mass.
Walworth Co., Boston.

"I'm glad to see you, Mr. Johnson"

Mr. Johnson is welcome because he is not merely another handshaker. He has always real news and definite ideas to contribute, and he brings to a conversation a fair-minded attitude and a keen intelligence.

He has a first-hand knowledge of the field, and of its latest developments. He seems to be able to see things from your side of the fence, too, and often offers many a workable suggestion.

Many men who welcome such a caller are neglecting interviews of even greater helpfulness—interviews with many Johnsons instead of one. Can you afford to miss "regular appointments" with the A.B.P. paper or papers that cover your field of industry?

Set aside—now—a definite time to go through your business papers carefully. You will find that it pays to set a time to go through every issue.

The membership of a publication in the Associated Business Papers, Inc. means that it conforms to the highest standards of editorial and advertising practice.

The editorial matter, written by experienced men who know the field and its needs, is measured by the standard: "Is it real news?" The paper is pledged, as all A.B.P. members are, to consider first the interests of the subscriber.

Readers can depend upon the character of advertising in an A.B.P. publication, and they cannot afford to neglect the advertising pages. Here are many practical suggestions for greater plant economy and more efficient operation that may well prove of great value in keeping abreast of developments in the fields of equipment and materials.

THE ASSOCIATED BUSINESS PAPERS, Inc.
Executive Offices: 220 West 42nd St., New York, N.Y.

A.B.P.

An association of none but qualified publications reaching 54 fields of trade and industry.

SIGNBOARD SECTION

Quick Action Opportunities

CLASSIFIED RATES

Advertisements in the Signboard Section which come under the classification "Position Wanted," "Help Wanted," "Salesmen and Agencies," "Business Opportunities," "Patent and Patent Attorneys" and "Technical Books" will be set in type as shown below and published at the rate of

50 cents a line

each insertion, 6 words to a line; minimum sold, 4 lines.

For display of any advertisement under the classified headings see sizes and rates in column at right.

DISPLAY RATES

Advertisements in Signboard Section which come under the classification "Equipment for Sale," "Equipment Wanted," "Educational and Instruction," and "Miscellaneous" are set in display space of the following sizes and at these rates:

1 in.	$ 5.50	4 in.	$20.80
2 in.	10.80	1 col. 8½ in.)	43.35
3 in.	15.90	2 col. (17 in.)	85.00

Not less than one inch to be sold in these classifications.

For advertising rates under other headings in this section, see column at left.

POSITIONS WANTED

POSITION WANTED: Engineer with 6 years' experience in all tests, calculations and analysis in steam plant. Also in heating and ventilating and paper mill machinery. Address Box 913, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

POSITION WANTED—Engineering graduate. Six years' practical experience in central stations and large industrial plant. Knows plant operation and electrical maintenance. Desires to move to a western state. Address Box 903, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

POSITION WANTED—Oper. Engr. maintenance or any position with a future. 12 yrs. exp. Corliss, Turbines, etc. Married, age 36. References. Location no object. Address Box 901, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

POSITION WANTED—As Sales Engineer or District Manager. Experienced on water tube boilers, turbines, engines, etc. Fine sales record and references. Address Box 910, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

HELP WANTED

ASSISTANT MECHANICAL ENGINEER, wanted by power plant and industrial piping contractor. Location, New York City. For position as assistant to district manager. Experienced in the design, estimating and installation of modern power plant, industrial piping and large heating installations absolutely essential. Prefer man age 28 to 35. Pleasing personality and sales ability a requirement. Salary dependent upon past record as shown. Address Box 916, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

HELP WANTED

WANTED by Contractor for power plant and industrial piping, Mechanical Engineer, experienced in the design and installation of power plant and industrial piping, also large central heating installations. Location, Massachusetts. Must be competent to independently estimate the cost of and supervise the installation of a large power plant piping or heating installation. Personality and sales ability an important factor. Prefer man 35 to 40 years of age. Salary entirely dependent upon previous record. A high-grade man is desired, capable of earning four to six thousand a year of more. This is an excellent opportunity for a man not afraid to work. The company now has offices in three cities and has other locations under consideration, each calling for a district manager in charge of operations. Detail experience with the piping of large central stations, industrial plants and heating installations is absolutely essential. Address Box 917, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

Engineering Office Manager

WANTED by contracting firm specializing in the installation of power plant equipment; prefer man about 35 to 40 with thorough knowledge of modern accounting system and with some knowledge of mechanical engineering subjects; experience with contracting or engineering office will be considered; position involves supervision of office force, bookkeeping, cost accounting, advertising, etc., and organization of office details; this is an excellent opportunity for the right man; salary will be commensurate with ability as proven. Address Box 914, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

PATENTS AND PATENT ATTORNEYS

PATENTS—Booklet free. Highest references. Best results. Send drawing or model for search and advice. WATSON E. COLEMAN, Registered Patent Lawyer, 724 9th Street, Washington, D. C.

SALESMEN AND AGENCIES

Sales Engineer

WANTED by power plant piping and equipment contractor; location, Boston. Must have acquaintance in power equipment field locally. Knowledge of power plant, industrial piping and large heating installations essential. Must have genuine sales ability. Salary will be commensurate with past record as shown. Address Box 915, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

AGENTS WANTED.—Unusual opportunities for establishing agencies to sell Stowe Forced Draft Stokers with their water-cooled walls. Air-cooled furnace walls and small stokers. Eastern Fields particularly attractive. Loyd R. Stowe, Sales Manager, B-19 Railway Exchange Building, St. Louis, Missouri.

AGENTS wanted to handle boiler room accessories. A live proposition. Pays big commission. Choice territory open. Dillon Automatic Flue Blower Co., 5600 Garfield Ave., Kansas City, Mo.

WANTED—Manufacturer's agents in following territory to sell an old established steam engine on commission basis: Baltimore, Md.; Norfolk, Va.; Atlanta, Ga.; Jacksonville, Fla.; Chattanooga, Tenn.; St. Louis, Mo.; Buffalo, N. Y.; Columbus, Cincinnati, Cleveland, Ohio; Los Angeles, San Francisco, Calif.; Indianapolis, Ind. Want live, aggressive agent who is already established in power plant field and who has close contact with power plants, architects, and industrial plant engineers. Give reference in first reply. Write Box 918, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

AGENCIES
(Exclusive)
and Enquiries Wanted.
The Universal Engineering Supply & Contracting Co.
119 Victoria Street, London, Eng.

SIGNBOARD SECTION
Quick Action Opportunities

EQUIPMENT WANTED

WANTED to buy either Rotary Convertor or Motor Generator Set of from 125 to 150 K.W. capacity, converting 220 V.-60 cycle 3-phase A. C. Current to 250 V.-D. C. Current. It must be of recent design, complete, and in A-1 condition.

B. S. Pearsall Butter Co.
Elgin, Illinois

Use this service to meet your business requirements

The scope of Signboard Section service is wide. That's why it is so successful and why it fits your requirements. Place your message under the classification suited for your particular appeal.

- Business Opportunities
- Education and Instruction
- Equipment For Sale
- Equipment Wanted
- Help Wanted
- Miscellaneous
- Proposals and Bids
- Patent Attorneys
- Patents For Sale
- Position Wanted
- Salesmen and Agencies
- Technical Books

Use the Signboard Section for Quick Action and Results

EQUIPMENT FOR SALE

A. C. UNITS and TURBINES
3 Phase, 60 Cycle, 2300/550/440/220 Volts

1000 KVA G. E. Alternator; with Erie Ball 4 valve Engine; new 1920; seen operating, $9,000.
750 KVA G. E. Alternator; dir. con. 30x34 Ames Uniflow Engine; 150 RPM; Exciter; S. B.; 3 years' service, seen operating, $9,000.
750 KVA (2) Wghse. Turbines (bleeder type), with Condensers; Exciters; S. B.; overhauled, seen operating, $7,800 each.
750 KVA (2) G. E. Turbines (back pressure 10 to 25 lbs.); Exciter; S. B.; 3 years' service, seen operating, $8,000 each.
625 KVA Wghse. Turbines (bleeder type); like new, $7,500.
375 KVA Al. Chal. Alternator dir. con. 20x36 Al. Chal. Corliss Engine; new 1919; few years' service, seen operating, $5,500.
375 KVA G. E. Turbine (bleeder type); Exciter and Condenser; 3 years' service, seen operating, $4,500.
250 KVA Wghse. dir. con. 21x22 Skinner Uniflow Engine; new 1923; seen operating, $5,500.
160 KVA G. E. Alternator dir. con. 18x24 Hamilton Corliss; practically new; seen operating, $3,000.
CONDENSER; Wheeler Surface, 755 sq. ft.; with Pumps complete, $1,000.

POWER PLANT EQUIPMENT CO., INC, 39-41 Cortlandt St., New York, N.Y

For Sale

4—250 HP. "Bass" Vertical Water Tube Hand-Fired Boilers, 150 lb. pressure.
1—30x48 Heavy-Duty Allis Engine.
1—28x54 Heavy-Duty H. O. R. Engine.
1—200-Kw. 240-v. Generator, D.C. to 20x36 Reliance Engine.
1—90-Kw. 250-v. Generator, D. C. to Heavy-Duty Ball Engine.
1—16-18¼ and 12¼x16 I. R. Compressor.
This equipment can now by inspected under power at Marion (Ohio) Works.

E. J. PAQUE, THE POLLAK STEEL CO.
Temple Bar Bldg., Cincinnati, O.

$2,200.00 Today Will Buy a Fine **Power Plant**

14x17" Chuse Uniflow Poppet Valve Engine.
72"x18' 150 H.P. H.R.T. 150-lb. Brownell Boiler.
Cookson No. 20 IXL Feed Water Heater. 6x4x6 Duplex Steam Pump.
Oil Separator, etc. All first class. Or will sell separately.

ZELNICKER — Walter A. Zelnicker Supply Company — St. Louis

Like prices on other Machinery, Rail, Equipment, Piling, Etc.

WHAT DO YOU NEED? WHAT HAVE YOU FOR SALE? Ask for Bulletin.

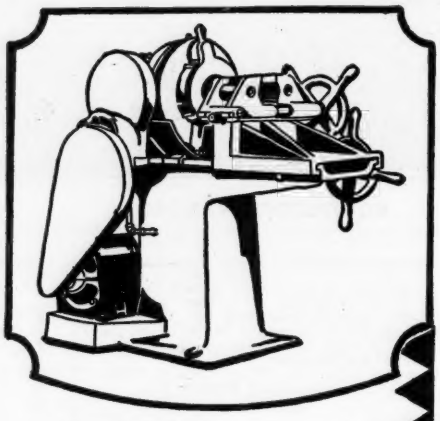
Diesel Engines
NEW AND LITTLE USED

200-hp. De La Vergne — never used.
500-hp. Busch, with 60-cy. alternator, splendid condition.
150 and 200-hp. Fairbanks-Morse Type Y, with 60-cy. alternators, complete outfits, little used.
40, 60, 100, 140, 150, 200, 280-hp. complete Diesel engines.

Robert P. Kehoe Machinery Company
7 East 42nd St., New York, N. Y.

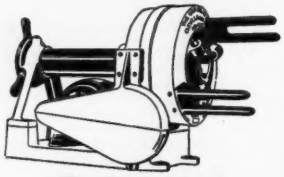
If you have any kind of equipment that is used in the power plant that has become inadequate for your needs—place a "for sale" message in the Signboard Section and dispose of it quickly. Your message will be seen and read by more than 22,500 prospective purchasers from coast to coast.

FOR thirty-three years the practical inventive genius of Oster engineers has been making pipe-threading a speedier, easier, simpler job. Particularly notable are Oster's remarkable accomplishments of the past three years—a period of progress never before equalled. That's why today the name Oster is everywhere synonymous with pipe-threading leadership.



Power Machines
Covering sizes from ¼" to 8".

Bull Dog Die Stocks
In 15 sizes for pipe from ¼" to 5"—plain or ratchet type.



The Power Boys
Quickly and easily moved—runs from a light socket—No. 412 for ¼" to 2", with auxiliary drive up to 4"; No. 414 for ¼" to 4", with auxiliary drive up to 12".

OSTER

OSTER tools reduce pipe maintenance costs because they are built to do more pipe-threading and repair jobs in less time and with less effort. The self-centering pipe guides and lever operated die heads of Oster die stocks, and the simplicity, speed and proved portability of Oster's famous Power Boys, are a few of the many features of Osters that get the jobs done in a hurry—and get them done better. They are all described in the Oster Catalog and Bulletin No. 71. A post card will bring them.

THE OSTER MANUFACTURING CO.
2045 East 61st Place .. .. Cleveland, Ohio

The Most Complete Line of Pipe-Threading Equipment in the World.

The nation's strength is the nation's health. Buy Christmas Seals and help preserve it.

THE NATIONAL, STATE, AND LOCAL TUBERCULOSIS ASSOCIATIONS OF THE UNITED STATES

Use the
Signboard Section
—it meets your
business requirements

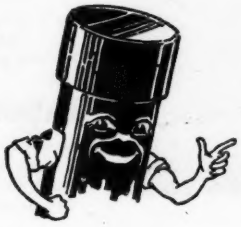
The scope of Signboard Section service is wide. That's why it is so successful and why it fits your requirements. Place your message under the classification suited for your particular appeal.

Business Opportunities
Education and Instruction
Equipment For Sale
Equipment Wanted
Help Wanted
Miscellaneous
Proposals and Bids
Patent Attorneys
Patents For Sale
Position Wanted
Salesmen and Agencies
Technical Books

The Signboard Section
brings Quick Action and Results

TRIMO

The Pipe does some talking:



Hey Trimo, you sure stand in with the boss. There are half a dozen pipe cutters around the shop here, but he wouldn't start cutting me up until he found his Trimo. How do you rate so high?

Trimo Pipe Cutter's answer:

I don't like to brag, my boy, but I guess the answer is that I know my stuff. A pipe like you ought to know that a Trimo always cuts fast and clean.

The Workman's comment:

I get kidded a lot for being fussy about my tools, but I know it pays. Take that Trimo pipe cutter for instance. I use it as a one wheel or a three wheel cutter and I never had any kick coming yet. All pipe cutters may look alike—but not to me. Give me a Trimo every time.

TRIMO

America's Leading Wrench Makers for Nearly Forty Years

TRIMONT MFG. CO., INC.
ROXBURY (BOSTON), MASS.

Don't Tear Down The Plant To Cut One Thread

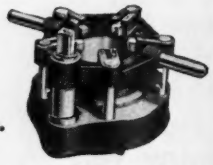
Repairs to and changes in pipe lines are as likely to occur in difficult, inaccessible places as any other.

Equipped with "Toledo" Geared Adjustable Threaders, you can thread pipe in place—you don't have to tear down the whole line.

The Tool slips in anywhere—the Ratchet handle works in close quarters. One man can thread up to 12" pipe—easily. The work is as good as could be done at a bench.

Your supply man has "Toledo's."

"TOLEDO"



The TOLEDO Pipe Threading Machine Co.
Toledo, Ohio, U. S. A.

Turn Dust Into Dollars

Give us the chance and we'll show you how you can make an actual money profit by installing

Tabco Cleaners

besides keeping your entire plant free from dust and its attendant fire hazard.

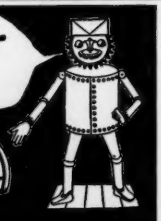
Write now for the proof

ALLEN & BILLMYRE CO. INC.
728 Grand Central Palace
New York City, N. Y.

BELT DRESSING FOR ALL BELTS

FREE ½ lb. Sample Bar

STEPHENSON BAR BELT DRESSING
PRESERVES BELTS · PREVENTS SLIPPING



Write your name, firm name, and address, on the margin of this page, tell us the kind of belt or rope drive to be treated, tear out, mail, and we will send FREE a half-pound sample bar of STEPHENSON.

We also have a 30-lb. 30-day trial offer. Want to learn about it?

Trade Mark Registered

STEPHENSON MFG. CO.
15 Spring, Albany, N. Y.

WM. W. NUGENT & COMPANY

411 N. Hermitage Ave., Chicago, U. S. A.
Builders since 1897 of

Oil Filters
Oiling Systems
Oiling Devices
Oil Pumps
Telescopic Oilers for Crosshead, Crank Pins & Eccentrics
Compression Pipe Fittings
Continuous Oil Filtering Systems Any Capacity

Milwaukee—548 Milwaukee St.
Detroit, Mich.—552 W. Jefferson St.
Waterbury, Conn.—111 Grand View Ave.
New York—9-15 Park Place, Room 1118
Philadelphia—1201 Chestnut St., Room 1104
New Orleans, La.—451 Howard St.
Pittsburgh, Pa.—30th St. & Liberty Ave.
Dallas, Texas—309-15 N. Market St.
Montreal, Que.—120 Prince St.
Vancouver, B. C.—1144 Homer St.
London, Eng.—10-12 Broad St. Ave.
Australia—273 George St., Sydney, N. S. W.
Manila-P. T.—25 Santa Cruse Bridge
Honolulu, H. I.—Honolulu Iron Wks.

The signboard is one of the oldest means of advertising.

Don't overlook the Signboard Section. Pages 114-115

The preferred babbitt

The choice of thousands of engineers because always uniform in composition, melts and pours well, and assures cool running, efficient and economical bearings.

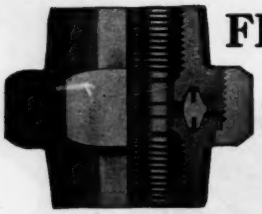
Government tests prove it to have the lowest frictional coefficient of any known bearing metal.

Magnolia Metal Co., 75 West Street, New York
Arlington Heights, Ill. San Francisco Montreal

MAGNOLIA
ANTI-FRICTION
METAL

REG. U.S. PAT. OFF.

In the metal line, specify Magnolia Products



Framanco Screw End Union showing renewable tapered joint—tight after many times making and breaking.

FRAMANCO

Trouble-Proof
FORGED STEEL
Fittings, Flange and Box Unions

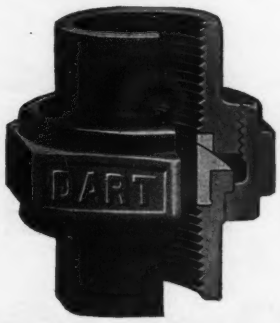
Made only by the
Continental Valve & Equipment Co.

Sales Offices and Works:
82 Herbert St., Framingham, Mass.

Chicago Office:
80 East Jackson Blvd.

Write for Full Information

For longer service



For leak-proof connections

SPECIFY DART UNIONS

Since the E. M. Dart Manufacturing Co. started making unions over thirty years ago, more and more of the leading plants of this country have tried the Dart Line and then standardized on these rustless and non-corrosive unions exclusively.

The bronze-to-bronze seats in Dart Unions are anchored in heavy malleable iron ends and ground together. A necessity for lines in the plant that receive the severest strains, Dart Unions are the economical unions.

Backed by a guarantee that insures two new unions if one proves defective, Dart is ready to save money in your plant.

Write for catalogue "T" and free sample union.

E. M. DART MANUFACTURING CO.

Providence, Rhode Island

Sales Agents: The Fairbanks Company, New York, and at all branches
Canadian Factory: Dart Union Company, Ltd., Toronto, Canada

Wanted—

The following issues of Power Plant Engineering:

Jan. 15, 1924 — April 1, 1924

Aug. 1, 1924 — Sept. 1, 1924

If you have a copy of any or all of these issues which you are willing to sell, please notify

POWER PLANT ENGINEERING

53 W. Jackson Blvd. Chicago, Ill.

OPEN STEEL IRVING SUBWAY FLOORING

Safety Under Foot

The standardized product of the world's largest steel flooring factory, backed by the resources and responsibilities which come with 24 years of experience. Write for Bulletin H-15.

IRVING IRON WORKS CO.
LONG ISLAND CITY, N.Y., U.S.A.

THESE BOOKS MAKE PROMOTION SURE!

HERE in seven handsome volumes is a complete education in power plant practice. Under the editorship of Terrell Croft, a staff of engineering specialists have put into the books everything the power plant man needs to know in order to get to the top.

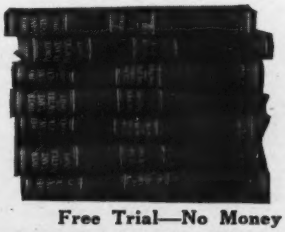
Power Plant Practice

7 Volumes—2795 Pages—3706 Illustrations

With the aid of this library hundreds of ambitious men have stepped into bigger jobs. You have the same opportunity. With a little spare-time reading you can have the identical knowledge possessed by the highest paid engineers.

With these books to guide you, you can fit yourself for the big-pay jobs in the power plant field.

The library covers the entire field—boilers—valve setting—engine operation—turbines—injectors—foundations—electrical machinery—combustion — refrigeration—fuels — governors — boiler stresses—fire tubes—feed water treatment—selection of boilers and engines—pumps and pump governors—steam traps—condensers—piping, etc.



Every page is packed with the kind of information that the power plant man needs in his daily work.

If you want to get ahead in your work—if you want to pass an examination for an engineer's license—if you want the big pay that comes with increased knowledge—get these books.

Free Trial—No Money Down—7c a Day!

FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York:
Ship to me, charges prepaid, the seven volumes of the POWER PLANT LIBRARY, price $16.00. If satisfactory, I will send $2.00 in ten days and $2.00 a month until the special price of $16.00 has been paid. If not wanted I will return.

Name .....

Home Address .....

City and State .....

Occupation or Position .....

Firm or Employer .....

PPE-12-15-27

"NATIONAL" Pipe FOR Power

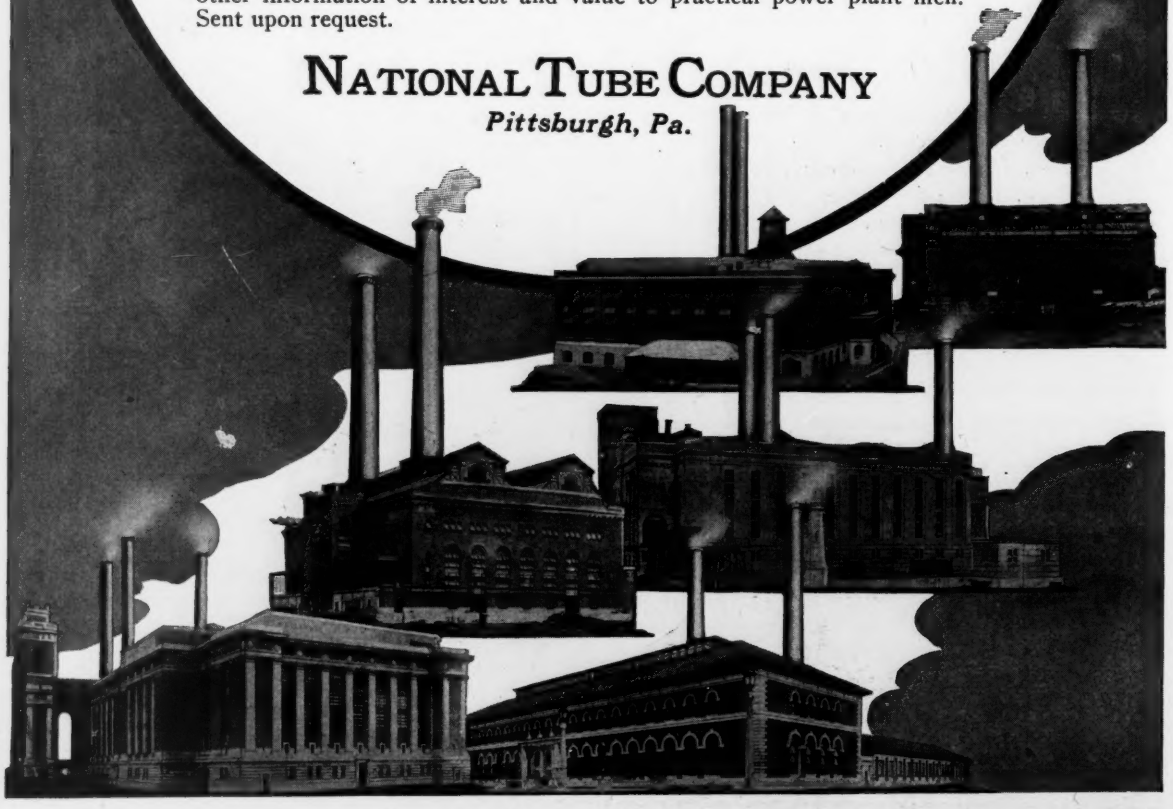
NOTWITHSTANDING the essential care needed in design and installation of equipment in the modern power plant—the keystone upon which successful operation depends is the reliability or dependability of the piping materials.

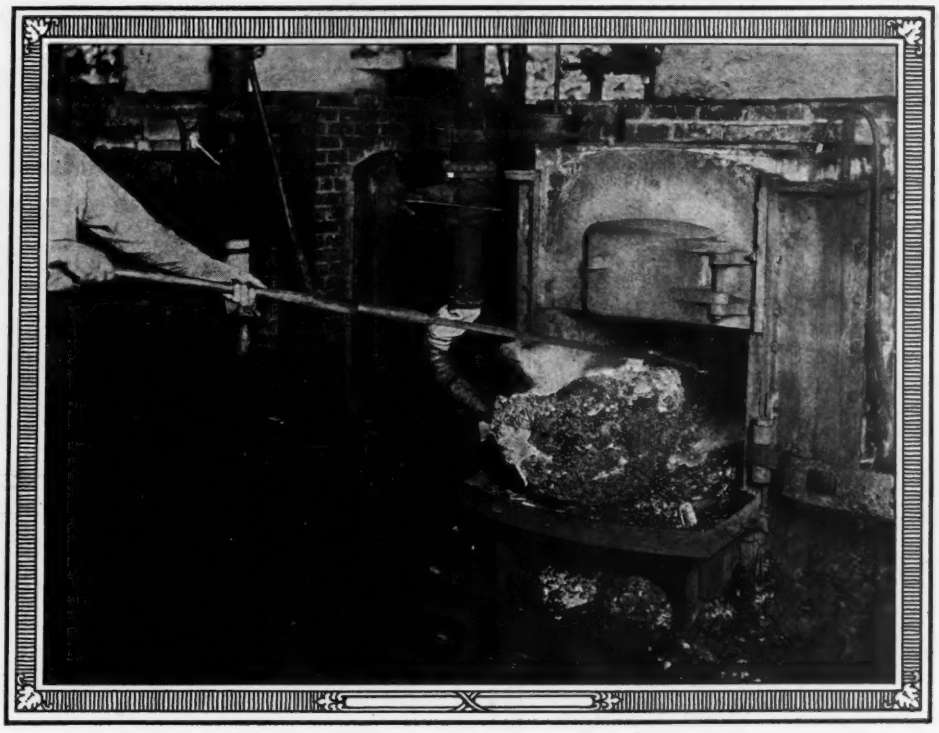
Throughout the system of pipe lines there can be no doubtful points—every foot of the way must be equally dependable and only pipe with a proved record of performance should be used where so much is dependent upon it.

The high tensile strength of "NATIONAL" Pipe—its sound welds—its dependability under a wide range of pressure and temperature conditions—its ductility and general uniformity—have made it the Recognized Standard for Power Purposes—as evidenced by its installation in many of the most advanced types of power plants in the country.

"NATIONAL" Bulletin No. 10 contains much pipe-engineering and other information of interest and value to practical power plant men. Sent upon request.

NATIONAL TUBE COMPANY
Pittsburgh, Pa.





THE FIRST AND MOST IMPORTANT STEP IN THE MAKING OF READING CHARCOAL IRON BOILER TUBES

QUALITY in Charcoal Iron Boiler Tubes begins with the efficient operation of the forge or knobbling furnace. Here the base metal is subjected to the action of burning charcoal and cold-air blast, which slowly melts it, eliminating impurities and leaving a lump of commercially pure charcoal iron.

Every pound of base metal which enters the knobbling furnaces in Reading's million-dollar Tube Mill must meet the most rigid requirements. And the men who operate the furnaces are selected for their long experience and unerring accuracy in this exacting work.

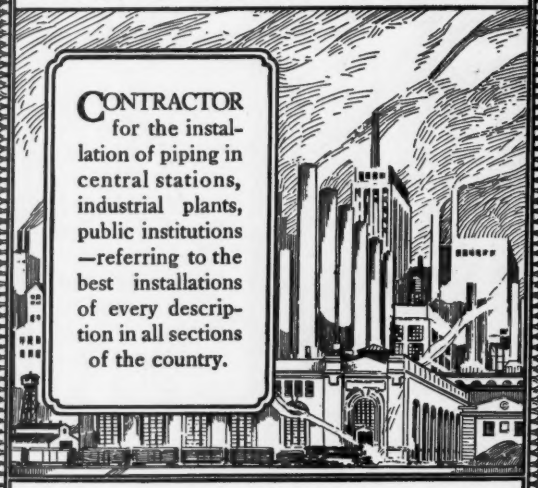
Reading Charcoal Iron Boiler Tubes represent the best that the finest men, machinery and materials can produce.

READING IRON COMPANY
READING, PA.
Also Makers of Genuine Wrought Iron Pipe

Baltimore	Minneapolis	Los Angeles	Cleveland
Boston	Cincinnati	New York	St. Louis
Buffalo	Detroit	Philadelphia	Shreveport
Chicago	Houston	Pittsburgh	Tulsa
	Seattle		

READING
CHARCOAL IRON BOILER TUBES

PIPING CONTRACTOR



CONTRACTOR for the installation of piping in central stations, industrial plants, public institutions —referring to the best installations of every description in all sections of the country.

WILLIAM A. POPE
Associates
WILLIAM H. MILLER R. A. WIDDICOMBE
S. AUSTIN POPE
26 North Jefferson Street, Chicago
Licensee: Sargol Joints (Patented)

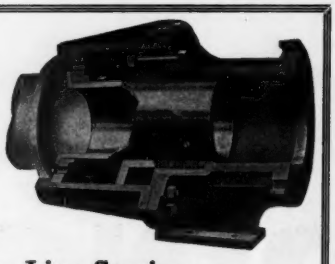
Contractors
for
Steam Power Plant
and
Industrial
Piping Installations
R.H. BAKER COMPANY INCORPORATED
Cambridge, Mass.
General Motors Building Detroit, Mich.
101 Park Avenue New York City

SEVENTY-FIVE years' intimate experience with piping in all its phases is responsible for outstanding quality of Grinnell fabricating service.
Address inquiries to Providence, R. I.
GRINNELL COMPANY

EVERBRITE Casting Metal
The Nickel Copper Alloy with unequalled casting properties, possessing exceptional strength and resistance to corrosion and erosion of steam at high pressures.
Send for Descriptive Booklet
AMERICAN MOND NICKEL COMPANY
CENTURY BUILDING · PITTSBURGH, PA.

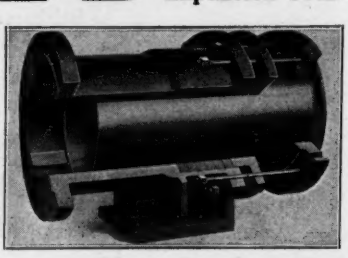
FABRICATION ERECTION
FORGE PIPE AND TUBING GAS WELDED HEADERS
HIGHEST SUPERHEATED STEAM PRESSURES AND TEMPERATURES
NAVCO
ALL TYPES PIPE JOINTS COMPLETE POWER PIPING INSTALLATIONS
NATIONAL VALVE AND MANUFACTURING COMPANY
PITTSBURGH PENNSYLVANIA U.S.A.
ATLANTA CHICAGO CLEVELAND COLUMBUS NEW YORK PHILADELPHIA

Howard
Guided
Expansion
Joint



For Pipe Line Service
Eliminates trouble from Expansion and Contraction, saves space, labor and repair bills; the construction is mechanically correct.
ALBERGER HEATER CO.
HOWARD IRON WORKS
285 Chicago St.
Buffalo, N. Y.

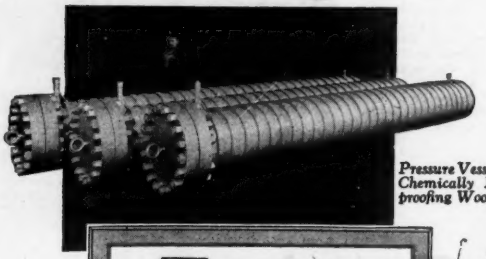
ROSS Internally Guided Expansion Joint
"Better Than Specified"
We Manufacture
Condensers: surface; low level jet; barometric; distilling.
Coolers: for oil, water, and all liquids.
Expansion joints: cross-head-guided and internally-guided.
Heat Exchangers;
Heaters: bleeder high and low pressure; boiler feed chemical, hot water system, oil storage, sugar juice.



ROSS HEATER & MFG. CO., Inc., Buffalo, N.Y.
Agents in all principal cities

Helpful Engineering Service

In many plants special problems arise that demand individual equipment to meet conditions exactingly. It is the duty of our engineering staff to determine or to develop equipment that will serve the particular purpose! Write.



Pressure Vessels for Chemically Fireproofing Wood.

POWER PIPING CO. • PITTSBURGH

The Babcock & Wilcox Tube Co.

Manufacturers of

SEAMLESS STEEL TUBES

THE BABCOCK & WILCOX TUBE CO.

For Stationary, Locomotive and Marine Boilers

For over twenty years, the Company's mills have been making high-grade tubes for Babcock & Wilcox boilers. The same careful selection of raw materials, close supervision of manufacture and rigid final inspection are followed whether the tubes are made for Babcock & Wilcox boilers or for any other purpose.

WORKS AND GENERAL OFFICES, BEAVER FALLS, PA.

New York, 85 Liberty St. — Chicago, Marquette Bldg.
Pittsburgh, Farmers Deposit Bldg. — Philadelphia, Packard Bldg.
Boston, 80 Federal St. — Cleveland, Guardian Bldg.

ATWOOD

ATWOOD

High Pressure Piping

ATWOOD

includes Standard Valves for all Pressures, Cast Steel Gate Valves, Non-Return Valves, Motor Operated Gate Valves, Cylinder Operated Gate Valves, Atwood Line Welds, Steam Separators, Interlock Welded Necks, Pipe Bends, Swedges, Joints of every description, etc. Write.

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION COMPANY

26th St. and A. V. R. R., Pittsburgh, Pa.

LUNKENHEIMER VALVES AND ENGINEERING APPLIANCES

ALL TYPES

THE LUNKENHEIMER CO.

"QUALITY"

CINCINNATI, OHIO, U.S.A.

NEW YORK CHICAGO BOSTON PITTSBURGH SAN FRANCISCO NEW ORLEANS LONDON

EXPORT DEPT. 129-135 LAFAYETTE ST., NEW YORK

AMERICA'S BEST LUNKENHEIMER QUALITY SINCE 1862

32-54-44

Pittsburgh Piping

MANUFACTURERS & CONTRACTORS

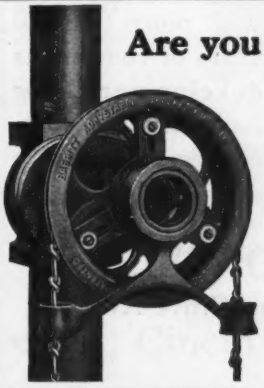
WHEN YOU THINK OF PIPING THINK OF PITTSBURGH PIPING — P&E.CO.

WE ARE fully equipped to supply fabricated materials and to install complete piping systems for Electric Power Stations, Blast Furnaces, Steel Mills, Coke Works and Industrial Plants of every description—backed by an experience of almost a quarter century.

PITTSBURGH PIPING & EQUIPMENT CO.

43rd St. and A. V. R. R., Pittsburgh, Pa.

New York, 220 Broadway — Chicago, Peoples Gas Bldg. — San Francisco, Call Bldg. — Cleveland, Ulmer Bldg.
Houghton, Mich., Dee Bldg. — Indianapolis, Traction Terminal Bldg. — Detroit, General Motors Bldg.
Boston, 10 High St. — Dallas, Texas, Am. Ex. Bank Bldg.



Are you waiting for ?

someone to break his neck before you put Babbitt Rims on your overhead valves?

Don't Wait! It's Bound to Happen if You Do!

Don't Delay! Buy Now! Safety First!

Babbitt Steam Specialty Co., Inc.

55 S. Water St.
New Bedford, Mass.

For SAFETY
and ECONOMY
specify
POWELL VALVES

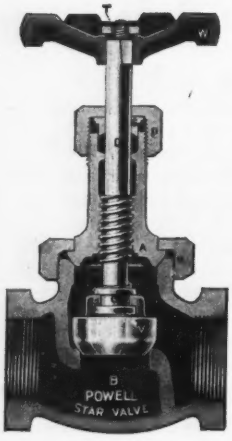


Fig. 110
Bronze Regrinding Model Star Globe Valve

Bronze, iron, and steel globe, angle, cross, check and gate valves—a valve for every purpose—as well as lubricators, oilers, grease cups, whistles, water and oil gauges, approved fusible plugs and a most complete line of engineering appliances comprise the Powell line.

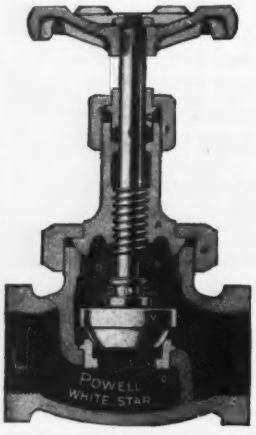
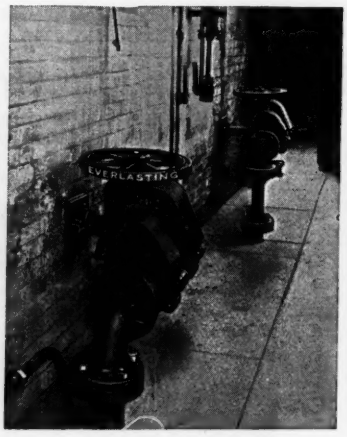


Fig. 102
Bronze Renewable Seat and Disc White Star Globe Valve

Standard in quality, distinctive in design, finest of workmanship, and truly finished products, thoroughly inspected and rigidly tested with more than 80 years of continuous development for longevity and economy in service.

THE WM. POWELL CO.
2521-2531 Spring Grove Ave.
CINCINNATI OHIO

THE Tandem Blow-Off installation shown at right, consists of two Everlasting Valves that function by one operation and always in the same sequence — one of many Everlasting Valve types.

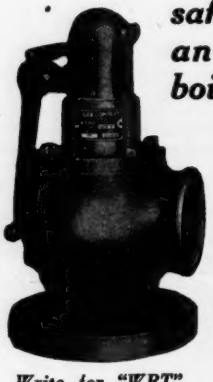


Everlasting Blow-Off Valves

give many years of service beyond their guarantee of two years' drop-tight service. Made for all working pressures and in types for every required service. Write.

Scully Steel & Iron Co.
P. O. Box 814, Chicago, Ill.

Lonergan
Pop Safety Valve Model "WRT"
—the latest and greatest safeguard to fire tube and return tubular boilers



Write for "WRT" booklet showing test figures compared with Code

Recent revisions in the A.S.M.E. Boiler Code indicate more rigid standards of practice. For 55 years it has been our business to serve power plants the world over with specialties that are BETTER THAN CODE.

You'll find that the new Lonergan Pop Safety Valve Model "WRT" exceeds the A.S.M.E. Code and other requirements by a wide margin.

The "WRT" booklet describes the features of this pop safety valve and gives the new code figures. It's worth having in every plant.

J. E. LONERGAN CO. 213 Race Street Philadelphia, Pa.
Established 1872
Export Office; Benj. Whittaker, Inc., 122 Greenwich St., New York

Golden-Anderson

Pat. Cushioned Automatic Controlling Altitude Valves

No Freezing in Winter.

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipes, Reservoirs, etc.
2. For High or Low Pressure. Always Dependable.
3. No Floats or Fixtures used.
4. No Water Hammer or Shocks.

Sizes to 24"

Golden-Anderson

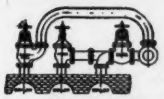
Pat. Automatic Cushioned Water Float Valves

½ to 24"

Automatically Maintain Uniform Water Levels in Tanks, Standpipes, etc.

Golden-Anderson

Patented Automatic Double-Cushioned Triple-Acting and Non-Return Valves



Double Extra Heavy Valves

"No Shutdown when a tube ruptures"

"No Explosion when a pipe bursts"

1. Automatically cut out a boiler the instant that a tube ruptures or other internal break occurs.
2. Automatically cut off the steam flow from every boiler the instant that a steam pipe bursts.
3. Automatically equalize the pressure between all boilers.
4. Automatically cut in a boiler, making accidents due to inaccurate steam gage impossible.
5. Positively prevent backflow of steam into a cold boiler.
6. Can be closed by hand, like ordinary stop valve, and arranged with "combination feature" to open valve like regular gate or globe valve.
7. Can be tested in service from the boiler-room floor.
8. Double Corliss Dash Pot that cushions in opening and closing.
9. Cannot pound, spin, stick or chatter.

Golden-Anderson Valve Specialty Co., 1287 Fulton Bldg., Pittsburgh, Pa.

Golden-Anderson

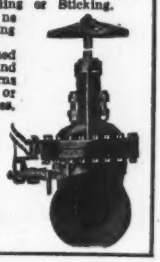
Pat. Automatic Cushioned Steam Pressure Reducing Valves

1. Maintain a constant reduced pressure.
2. Thoroughly cushioned.
3. No hammering, chattering, or sticking.
4. No auxiliary valves or small by-passes to clog up.
5. No wire drawing.
6. Only one adjustment from the outside.
7. Double extra heavy throughout — practically indestructible.

Golden-Anderson

Pat. Cushioned Combined Throttle and Automatic Engine Stop Valves

1. Operate 3 ways: Automatically, by Hand, or by Electric Switch.
2. Prevent Fly-Wheel Explosions.
3. "Double Corliss" Cushioned —No Pounding or Sticking.
4. Contain no Tight Fitting Parts.
5. Furnished in Angle and Globe Patterns for High or Low Pressures.
6. "Always Ready for Service."



Cuts valve costs in half

COSTS count in these days and the cost of a valve is by no means its first cost. Figured on the cost per year of leak-tight service, Reverso Valves win their way with the closest buyers.

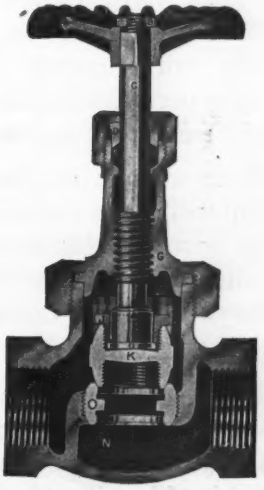
Both seat and disc being easily reversible, the life of Reverso is doubled by this feature alone with no extra expense. Then each side of both the seat and disc are good for many regrindings.

Leading industries are specifying Reverso because of the unusual records they are making in economy. Engineers prefer them because of the time, trouble and repairs they save.

Order from your dealer and see for yourself. Write for bulletin No. 15.

REVERSO: Bronze Body for 200 lbs. Pressure. Total Temperature, 550° F.

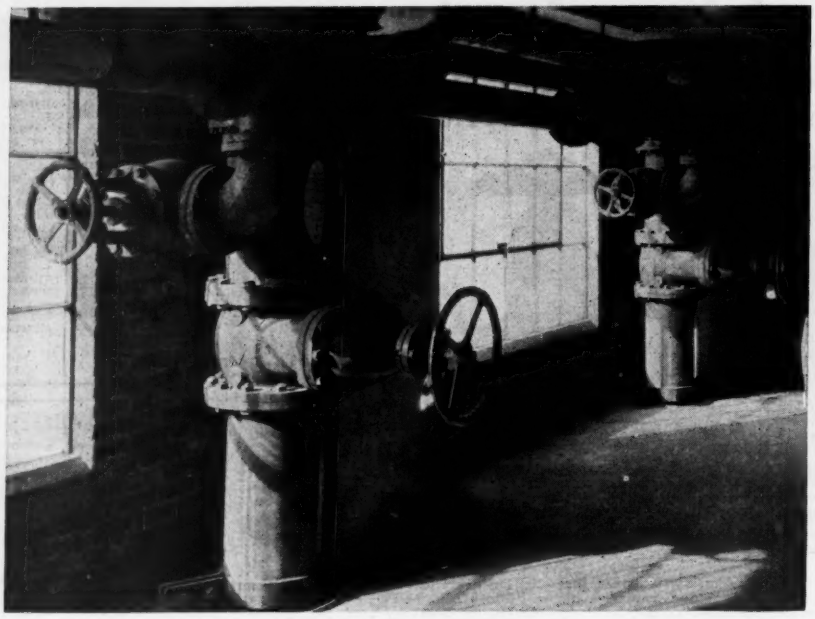
IROVERSO: Iron Body for 150 lbs. Pressure. Total Temperature, 450° F.



REVERSO

The Valve with the Reversible Disc & Seat

The D. T. Williams Valve Co., Cincinnati, Ohio



Jenkins Iron Body Gate and Angle Valves on syrup lines in syrup station

A place in the sun

For many years Jenkins Valves have enjoyed "a place in the sun"—a position fairly earned by a valve performance that engineers can count on.

Pictured here are Jenkins Valves in the sunlit service room of the Brooklyn refinery of the American Sugar Refining Company.

They are Standard Iron Body Gate and Angle valves, 12″ and 8″ respectively, used in the exacting work of handling syrup.

Engineers who seek maintenance economy are guided in their valve selection by the Jenkins Diamond Mark. Look for this symbol of service on bronze and iron valves, in standard, medium and extra heavy patterns. At supply houses everywhere.

JENKINS BROS.
80 White Street.....New York, N. Y.
524 Atlantic Avenue.....Boston, Mass.
133 No. Seventh Street....Philadelphia, Pa.
646 Washington Boulevard....Chicago, Ill.
JENKINS BROS., Limited
Montreal, Canada.....London, England
FACTORIES:
Bridgeport, Conn.....Elizabeth, N. J.
Montreal, Canada

Always marked with the "Diamond"
Jenkins Valves
SINCE 1864

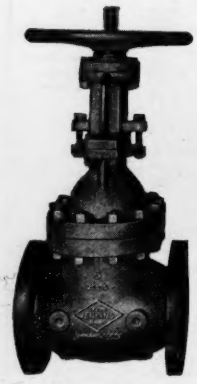


Fig. 204
Jenkins Extra Heavy Iron Body Gate Valve, Flanged

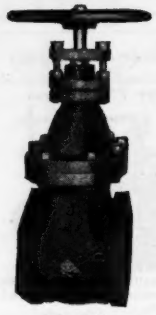


Fig. 325
Jenkins Standard Iron Body Gate Valve, Screwed

Fig. 144
Jenkins Standard Iron Body Angle Valve, Flanged

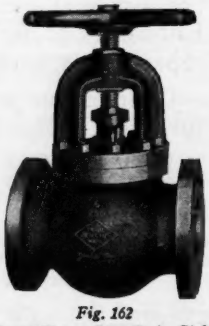
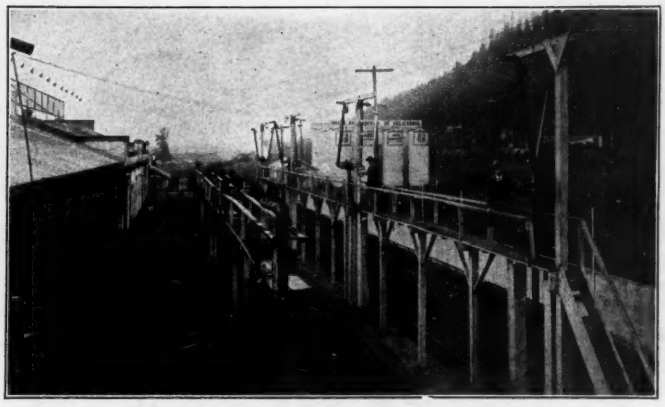


Fig. 162
Extra Heavy Iron Body Globe Valve, Flanged

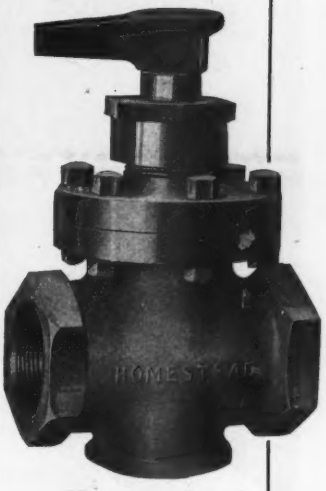
VALVES *of* LASTING SERVICE

Three-Way Quarter-Turn with screwed ends.



Every valve is a Homestead on the loading rack at the Union Oil Co. plant at Portland, Ore., shown at right.

In America's Leading Industries



Homestead 500-lb. Pressure Straightway Quarter-Turn Valve

In the Oil Industry *they also serve*

Four-Way Valve with screwed ends.

CAN you better afford to waste oil than the great oil-producing and refining companies who have standardized on Homestead Quarter-Turn Valves because they give years of leak-tight, trouble-free service?

Oil is money, pressure is money, and so is steam, air, gas, hot and cold water, and all the other liquids and gases of industry.

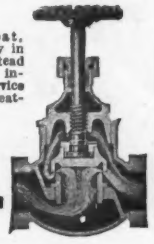
To guard them, power plants and factories, mines, mills, railroads—all industries—turn to the Homestead Quarter-Turn Line for the valves that have proved their endurance for over 35 years.

There's a Homestead Quarter-Turn Valve for every service—some of specially developed metals to resist various chemicals, and also high temperatures; the Lubricated line that works where others fail, and sizes, types and fittings to meet any conditions of piping layout.

Let us send you this valve booklet free

Twenty-four pages, show a few of the hundreds of installations of Homestead Valves in industry. Handsomely illustrated.

Protected Seat, as found only in this Homestead Globe Valve, insures long service and tight seatings.



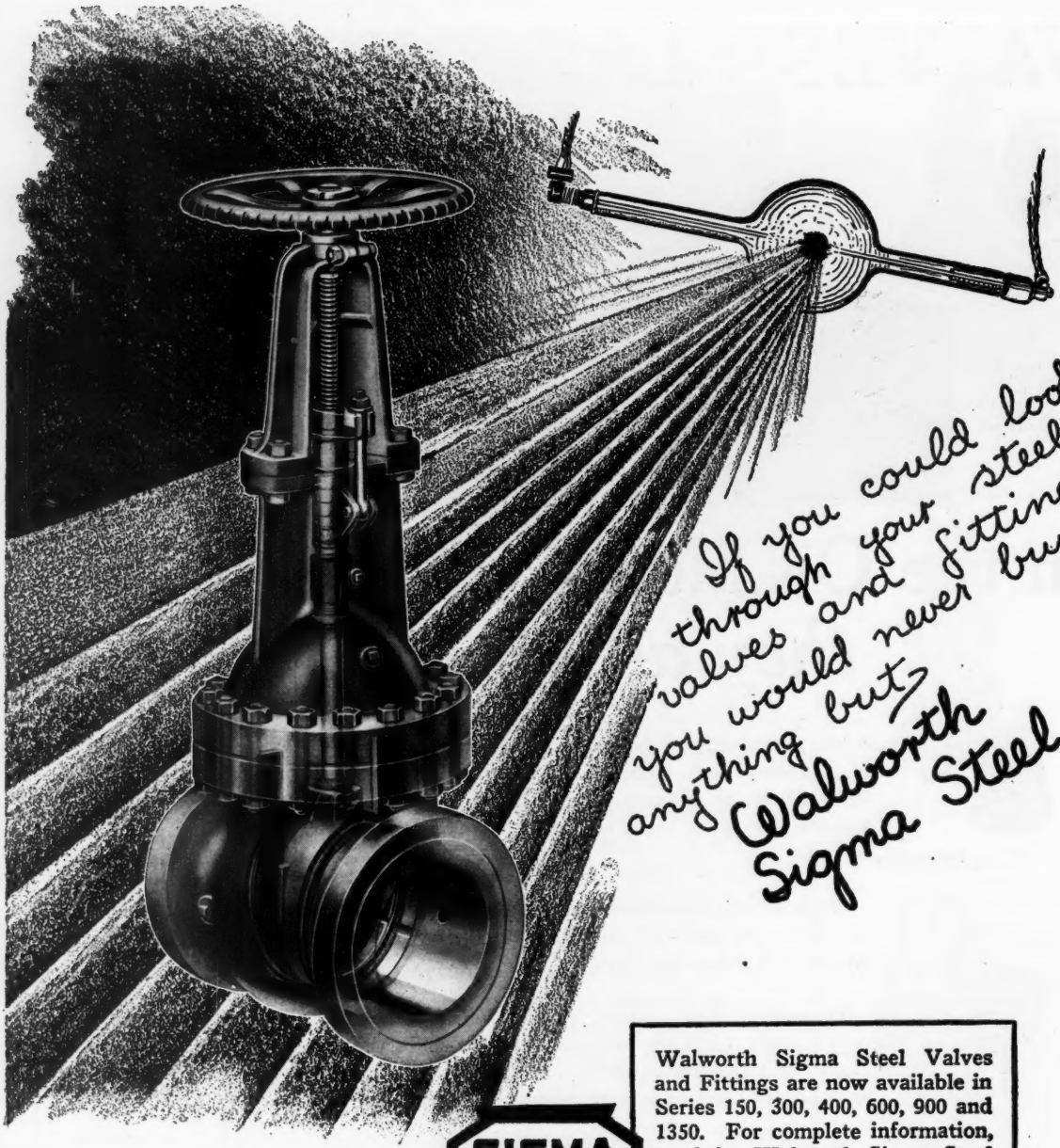
Hovalco Valve, at left, and a Quarter-Turn Valve, above, make the Homestead ideal combination on blow-off service.

Homestead Valve Manufacturing Company, Homestead, Pa.

HOMESTEAD VALVES

QUARTER TURN VALVES:
STRAIGHT WAY
THREE WAY
FOUR WAY
LUBRICATED TYPE
ROUND OPENING REFINERY

PROTECTED SEAT VALVES:
HYDRAULIC (B & O. PAT.) OPERATING
REMOTE CONTROL
GLOBE
ROSS AIR SHUT-OFF VALVE
HOVALCO BLOW-OFF VALVE



If you could look through your steel valves and fittings you would never buy anything but Walworth Sigma Steel

Walworth Sigma Steel Valves and Fittings are now available in Series 150, 300, 400, 600, 900 and 1350. For complete information, send for Walworth Sigma Steel Bulletins Nos. 1 to 12.

SIGMA HAS SWEPT SUSPICION FROM STEEL TRADE MARK

WALWORTH

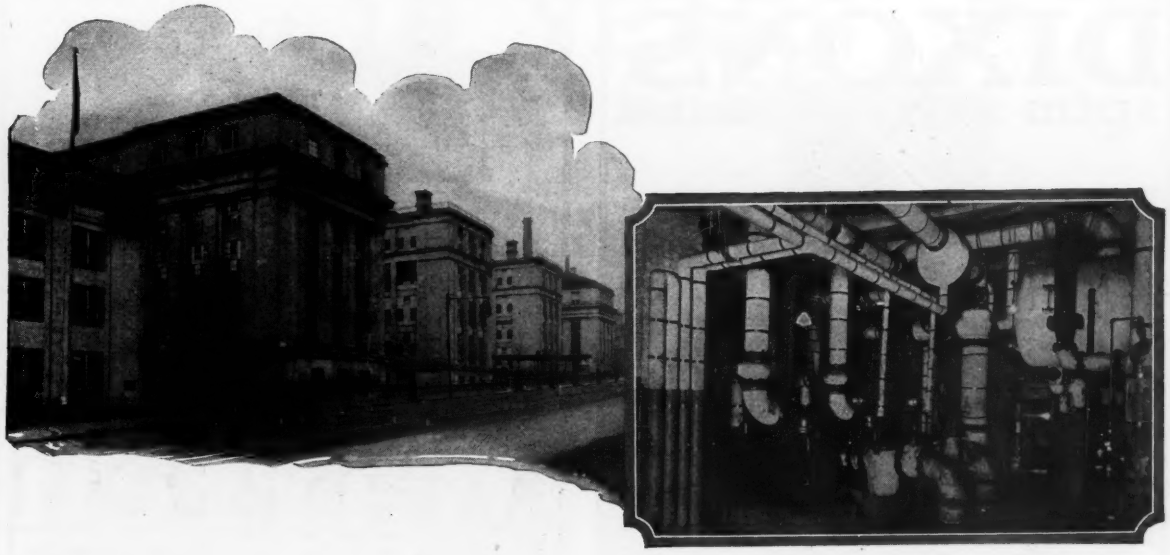
Walworth Company, General Sales Offices: 51 East 42nd St., New York

Plants at Boston, Mass.; Kewanee, Ill.; Greensburg, Pa., and Attalla, Ala.

Distributors in Principal Cities of the World

Walworth Co., Limited, 10 Cathcart St., Montreal, P. Q.

Walworth International Co., New York, Foreign Representative



Helping to put new greenbacks into circulation

50th Anniversary 1877-1927

THE Bureau of Engraving and Printing at Washington, D. C., where our paper currency is printed, is one of scores of public buildings which are being served by Kennedy Valves.

Year after year, these valves have been faithfully doing their share in the proper functioning of this important government plant. Their operation has been thoroughly reliable, with practically no attention or maintenance expense.

Your own plant deserves the same kind of valve service that Uncle Sam is getting here. It will pay you to standardize on Kennedy Valves. The Kennedy line of valves, pipe fittings and fire hydrants includes valves for all requirements from high pressure superheated steam to exhaust steam, from large size condenser circulating water systems and municipal water mains to little service lines, and for oil, air or gas lines.

Send for the Kennedy Catalog.

The Kennedy Valve Mfg. Co.
Elmira, N. Y.

New York Boston Chicago San Francisco Philadelphia Cleveland
Atlanta Los Angeles El Paso Seattle

KENNEDY

VALVES-PIPE FITTINGS-FIRE HYDRANTS

DIXON'S
SOLID BELT DRESSING

To Abolish Belt Slip

and to deliver more power to your driven shafting and machinery, apply Dixon's Solid Belt Dressing to every leather, fabric and rubber belt in your plant.

It will keep the belts soft and pliable with a more positive grip on the pulley surfaces over the maximum arc of contact.

A true belt preservative that will greatly increase the life of every belt.

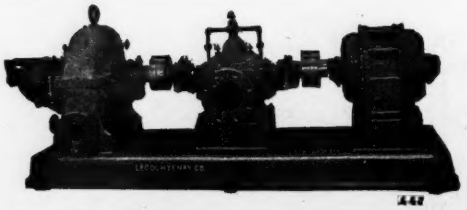
Dixon's Solid Belt Dressing does not harden, cut or clog the belt. Its high efficiency and economy are proved by many years' use in thousands of factories, machine shops and power plants.

Safe to apply with the belt running at full speed. A little applied at a regular interval is the best way to keep your belts in prime condition continuously.

Handy in size, 2 in. x 8 in. The weight is about 1 lb. Does not deteriorate in storage.

Write for Belt Dressing Circular No. 94-O.

Joseph Dixon Crucible Company
JERSEY CITY, NEW JERSEY
Established 1827



CENTRIFUGAL *Pumps*
Made in capacities up to 20,000 GPM and heads to above 1000 feet.

LECOURTENAY COMPANY
7 Maine Street, Newark, N. J.

Warren
High grade centrifugal and reciprocating pumps for every power plant service. Designed, built and tested for years of dependable service at least cost for operation and maintenance.
WRITE FOR BULLETINS
WARREN STEAM PUMP COMPANY, Inc.
Warren, Mass.
Pumps

DETROIT UNDERFEED STOKERS
Ask For Bulletin 879
Detroit Stoker Company
879 General Motors Bldg - Detroit.

WORTHINGTON

PUMPS
Steam and Power
Reciprocating and Centrifugal

COMPRESSORS
Air, Gas and Ammonia
—Air Lifts

CONDENSERS
Surface, Jet, Barometric
—and vacuum auxiliaries
Steam-Air Ejectors

ENGINES
Oil and Gas

FEED WATER HEATERS
Locomotive and Stationary

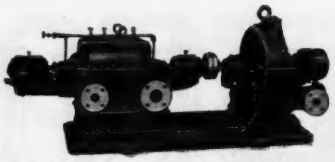
METERS
Water and Oil

Worthington Pump and Machinery Corporation
115 Broadway, New York City

HUBER STOKERS
Mechanical Stoker Hand Stoker (heavy duty)
Semi-Mechanical Stoker Hand Stoker
A Stoker for Every Boiler
Send for a Copy of
"Five Minutes With the Coal Bill"

FLYNN & EMRICH COMPANY
307 North Holliday Street Baltimore, Maryland

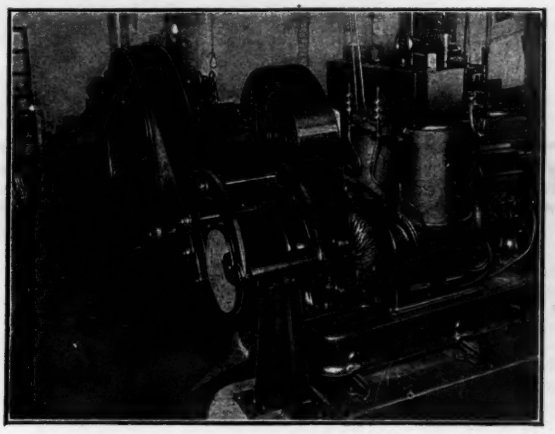
FREDERICK PUMPS

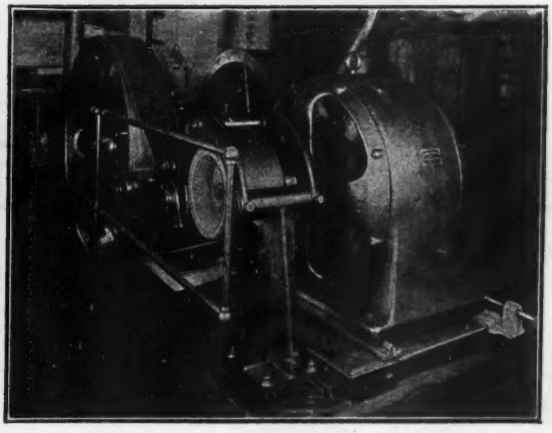


Single and multi-stage centrifugal pumps for every kind of pumping service.

The Frederick Iron & Steel Company
Frederick, Maryland

19 YEARS STEADY SERVICE





65 H.P. Steam Engine driven Generator
Pulley centers 6′ 6″

THE original open drive connecting a 65 H.P. steam engine and a bi-polar generator on 16′ 0″ centers gave continuous trouble because of excessive belt slippage.

In 1908, a LENIX was installed, as illustrated above at the left. The LENIX eliminated all actual belt slippage, gave efficient transmission of the power and, in general, improved the operating conditions. Incidentally, the LENIX permitted the installation of these units on 6′ 6″ centers, saving about ten feet of valuable floor space.

For **seventeen years,** this installation was in daily service and, with the exception of one new belt, the outlay for upkeep was, in the words of the superintendent, "not a cent."

In 1925, the old steam engine and generator was replaced by modern units, and as illustrated above at the right, the old LENIX was used with the new equipment.

This record of over **nineteen years** of daily service is proof of the reliability and soundness of design and construction of the LENIX. This installation is only one of many still in service after nearly twenty years of operation. There are now thousands of LENIXES installed on drives in units from 1 H.P. to 1400 H.P. in practically every industry.

The Lenix Saves

Power
Building Space
Belting
Bearing friction
Lubrication
Maintenance cost
First cost of motors, generators, etc.
On drives 1-1400 H.P. and up.

The LENIX is the pioneer short center belt drive. Our extensive experience, the result of more than twenty years of designing and building LENIXES, is offered for the solution of your belt drive problems.

A card will bring you full information.

The LENIX DRIVE

(Trademark Reg.)

F. L. SMIDTH & CO.

Engineers

52 Church Street New York, N. Y.

DEPEND ON SULLIVAN AIR POWER

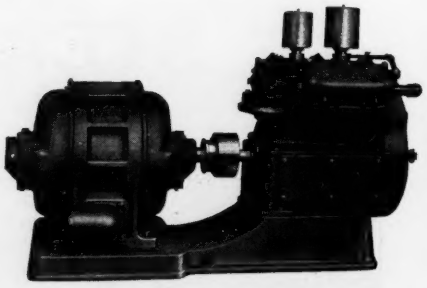
Do you need—

100 to 240 cu. ft. of air per min., plus
Small floor space?
Easy portability?
Direct motor drive?
Automatic or hand control?
Continuous, vibrationless operation?

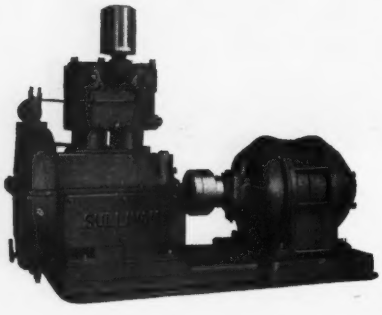
These advantages are offered by the new Sullivan "WL-22" 2 cylinder, and "WL-44" 4 cylinder vertical type compressors shown here.

For the shop or power plant that is short of floor space—for isolated departments in large plants—for standby or night service—or for the contractor desiring a semi-portable air unit, these compressors will be most attractive.

These new compressors are direct driven by electric motors, and both compressor and motor are mounted rigidly on a one-piece cast iron base.



NEW SULLIVAN VERTICAL COMPRESSORS



Special Features

Special features of these machines are "Wafer" inlet and discharge valves, sweep-control unloading device, positive automatic lubrication, and full water cooling of cylinder barrels and heads. They are adapted to push button, automatic, or combination push button and automatic, start and stop control.

"WL-22" has a floor space 6 x 2½ ft.; "WL-44," 6 x 3 ft.

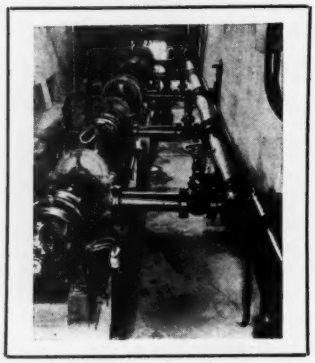
You will want to know more about these balanced "Vibrationless" compressors.

Write for Catalog 6283-H.

SULLIVAN MACHINERY COMPANY
301 Peoples Gas Bldg., Chicago

SULLIVAN

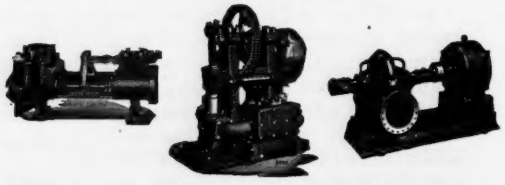
OVER 200,000 AMERICAN-MARSH PUMPS IN SERVICE



Servicing Diesel engines, Commerce Mining & Royalty Co., Miami, Okla.

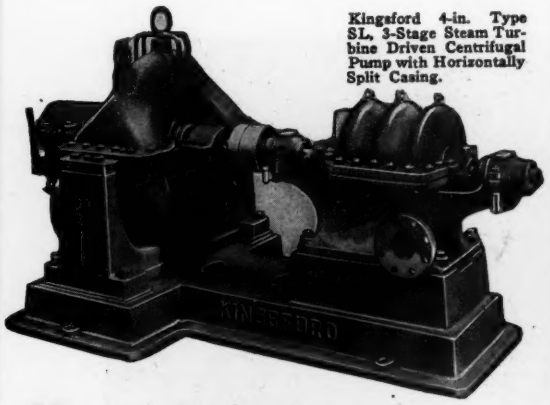
WHEN you select American-Marsh equipment, you have placed your requirements with a recognized leader in the industry. No other manufacturer of steam and centrifugal pumps can offer you a more capable engineering service, or deliver you a finer product. Consult with us on any type of pumping problem. Write for American-Marsh Bulletins.

AMERICAN-MARSH
PUMPING EQUIPMENT
American Steam Pump Company, Battle Creek, Mich.



Platt Iron Works
Dayton, Ohio
"Platt" and "Smith-Vaile" Pumps
Steam and Power Pumping Machinery

YEOMANS PUMPS ELECTRIC STEAM GASOLINE
SEWAGE - BILGE - FLOOD
FIRE - DRAINAGE - CONDENSATION
and BOOSTER PUMPS
Catalog on request
YEOMANS BROTHERS COMPANY
1432 Dayton St., CHICAGO
Representatives in all principal cities



Kingsford 4-in. Type SL, 3-Stage Steam Turbine Driven Centrifugal Pump with Horizontally Split Casing.

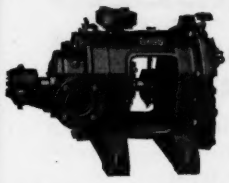
KINGSFORD
Centrifugal Pumps

Here is the latest development of our experience of over 58 years as builders of power plant equipment, a boiler feed unit built for speeds up to 3600 r.p.m. and pressures up to 400 lbs. We also build Centrifugal Pumps for all services, Boilers and Engines.

Send for Bulletins

Kingsford Foundry & Machine Works
Oswego, New York

MANISTEE
"ROTURBO"
CENTRIFUGAL PUMPS
ROTARY JET CONDENSERS
Manistee Iron Works Co. Manistee, Mich.



Centrifugal Turbo Boiler Feed Pumps
Single Unit Design
Automatic Operation

Steam Turbines
Rugged 1 to 60 H.P. Reliable
Coppus Engineering Corporation
340 Park Ave., Worcester, Mass.
COPPUS FORCED DRAFT BLOWERS

GARDNER-DENVER
Packed Piston Pump,
Motor Drive

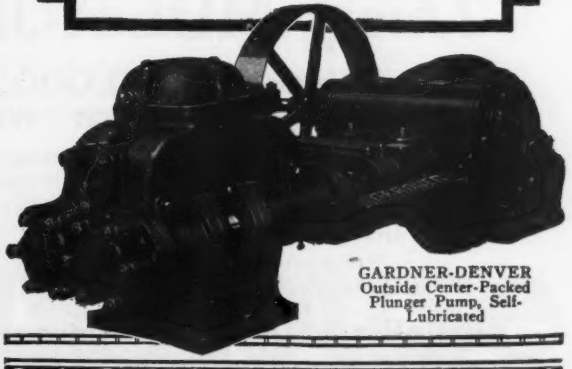
Goodbye to the drudgery of oiling pumps!

The daily drudgery and expense of oiling pumps—too often "half-oiling" them—has been eliminated by the GARDNER-DENVER Enclosed Self-Lubricated power pumps. Oiled once a month, in one place, these pumps accomplish a real saving of time, labor, oil and wear. Industrial plants everywhere are adopting this equipment.

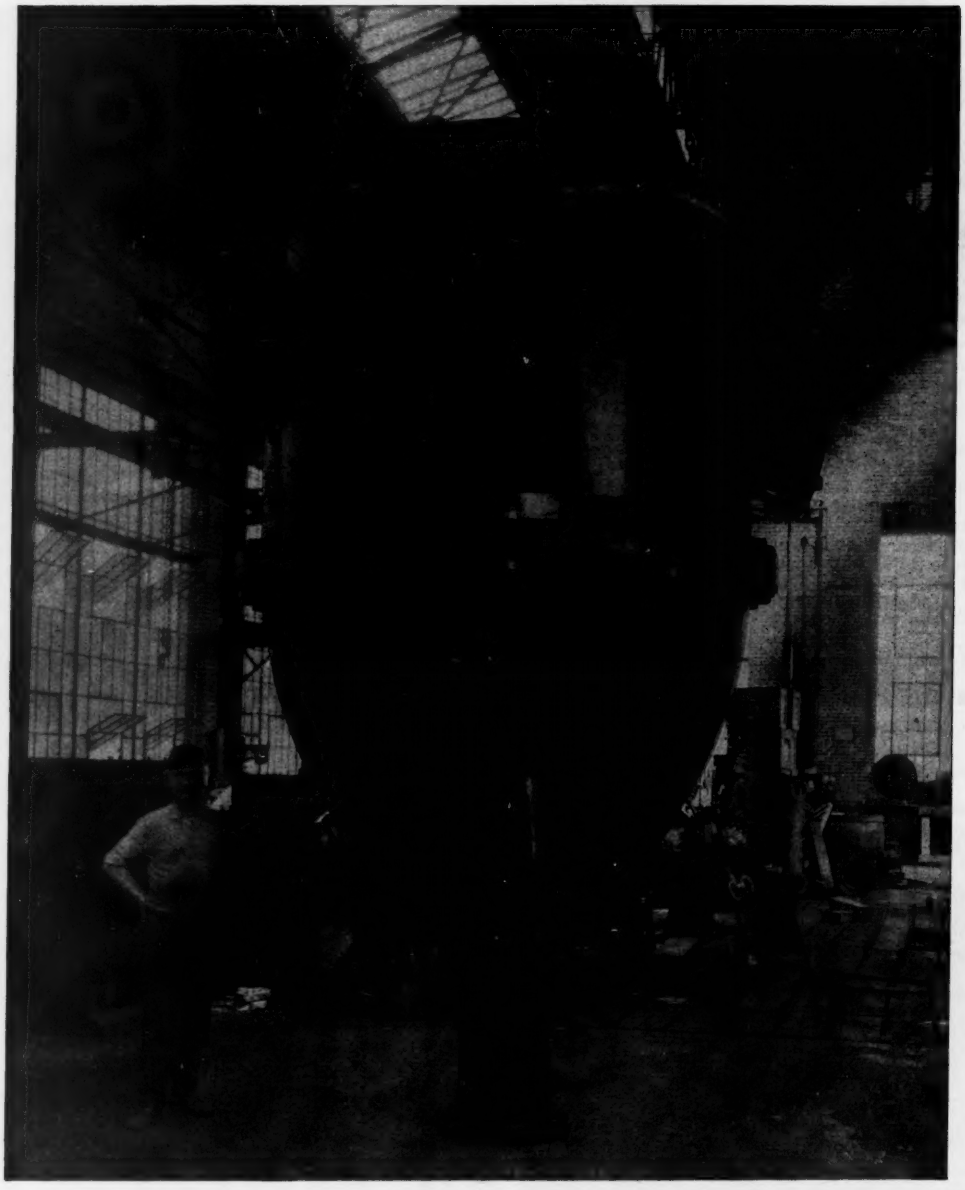
Ask for Bulletin EP-3.

"Quality Builders for Over 65 Years"

GARDNER-DENVER COMPANY
Headquarters at
Quincy, Ill. Denver, Colo.
Sales Offices Throughout the World



GARDNER-DENVER
Outside Center-Packed
Plunger Pump, Self-
Lubricated



This MULTI-JET CONDENSER

will handle 100,000 lbs. of steam per hour at high vacuum without an air pump

The water jets produce the vacuum by condensing the steam and maintain the vacuum by entraining the air and gases.

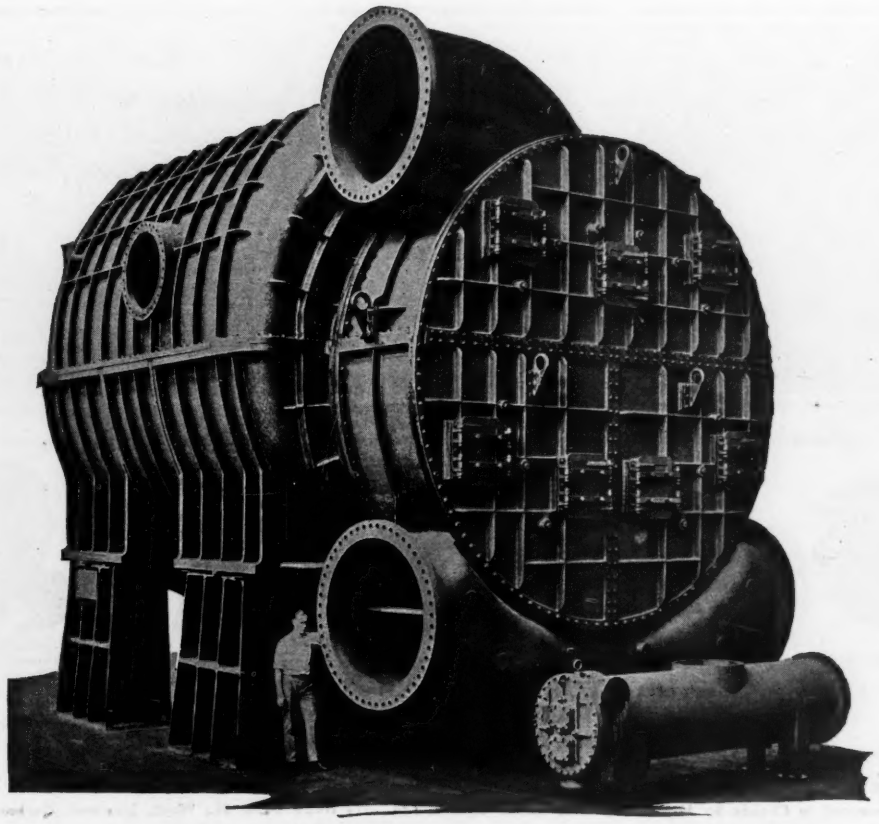
30 standard sizes. Capacities 100 KW. to 10,000 KW. High or low level arrangements.

Recommended for engines, turbines, evaporators, vacuum pans, dryers, etc.

Send for Bulletin 5A and list of installations (over 400 in service).

Install a Multi-jet Condenser and avoid air pump troubles

SCHUTTE & KOERTING CO., 1156 Thompson Street, PHILADELPHIA, PA.



Westinghouse 70,000 sq. ft. Condenser

Westinghouse 700 sq. ft. Condenser

Large *or small*

THE same qualities of workmanship and design are embodied in Westinghouse condensers from the largest to the smallest.

On large condensers where the tube nest is large, a steam belt completely surrounds the tube nest and on small condensers with the small tube nest, a large steam space extends the full length of the tubes. These designs insure even distribution of steam to all tubes and a minimum pressure drop from steam inlet to air offtake.

Westinghouse condensers are served by Westinghouse condenser auxiliaries which are designed especially for condenser service, allowing maximum efficiencies.

These features of Westinghouse condensing equipment economically produce high vacua and coupled with Westinghouse service insure satisfaction.

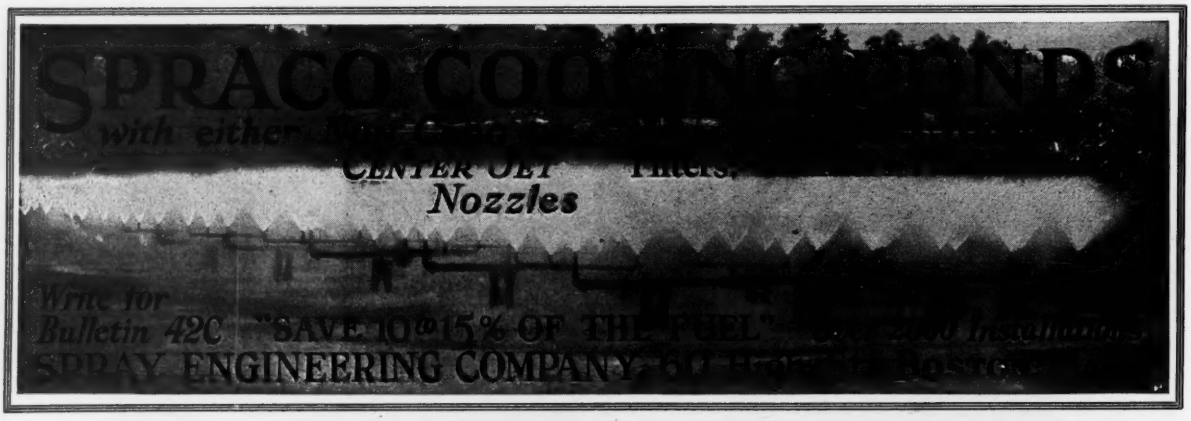
Power Plant Equipment
Including

- Turbines
- Generators
- Head Lighters
- Stokers—for every coal burning requirement
- Surface Condensers and auxiliaries
- Jet and Barometric Condensers
- Air Ejectors
- Reduction Gears
- Generator Air Coolers

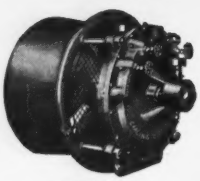
Westinghouse Electric & Manufacturing Company
South Philadelphia Works Philadelphia, Pa.
Sales Offices in All Principal Cities of the United States and Foreign Countries

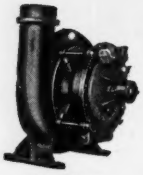
Westinghouse

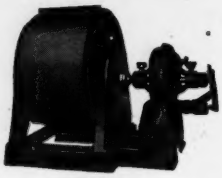
X95524

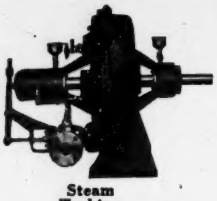


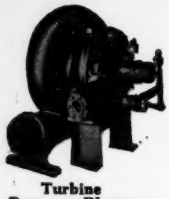
Write for Bulletin 42C "SAVE 10@15% OF THE FUEL"
SPRAY ENGINEERING COMPANY, 60 [illegible] BOSTON


Turbine Propeller Blower


Up Blast Volume Blower


Stoker Fan

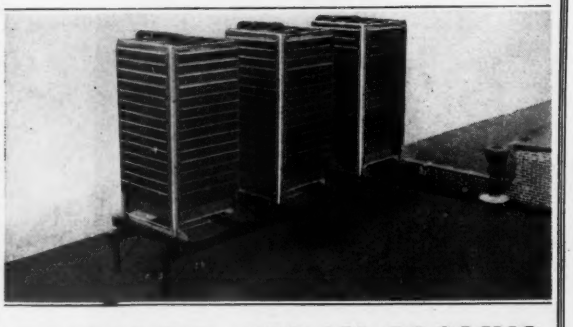

Steam Turbine


Turbine Pressure Blower

ALL CARLING TURBINES AND TURBINE BLOWERS PROTECTED BY PATENTED SAFETY DEVICE WHICH PREVENTS RUN-AWAY. FURTHER DETAILS ON REQUEST

CARLING TURBINE BLOWER CO. WORCESTER, MASS.

Represented in Canada by Mason Regulator Co. of Canada, Ltd., 314 Notre Dame St., West., Montreal, Quebec



BINKS SPRAY COOLING TOWERS

Capacity 30 to 100 Gallons per minute

Combines every spray cooling requirement in one compact unit requiring a space of only 6x7½ ft. For roof or ground use. Sturdy, extra heavy galvanized steel frame with cypress louvres and collecting pan. Maintenance costs are negligible. Recirculates water with less than 2 per cent loss. Installed in single units or in series. Add units as requirements grow.

Write for descriptive "Bulletin 5-E."

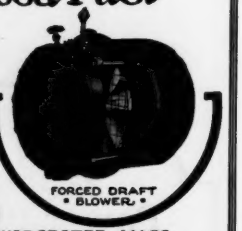
BINKS SPRAY EQUIPMENT CO.

Dept. M, 3130 Carroll Ave., Chicago, Ill.

Offices in Principal Cities

Increased Boiler Rating With Low Priced Fuel

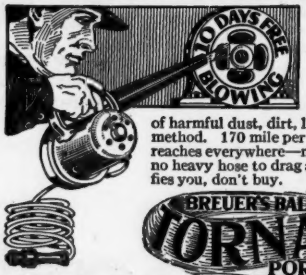
A result of Coppus Forced Draft Blowers



DO NOT CHANGE YOUR CHIMNEY OR PUT IN ANOTHER BOILER BEFORE READING BOOKLET NO. 145.

REGISTERED COPPUS U.S. PAT. OFFICE ENGINEERING CORPORATION
340 PARK AVE. WORCESTER, MASS.

CENTRIFUGAL TURBO BOILER FEED PUMPS • STEAM TURBINES • MINE VENTILATING BLOWERS



Blow Out ALL Dust with 170 Mile P. H. Gale of DRY Air!

Keep motors, machinery, line-shafting, bins and equipment free of harmful dust, dirt, lint, etc. Fastest, safest, cheapest method. 170 mile per hour gale of CLEAN, DRY air reaches everywhere—no condensed moisture. No tank, no heavy hose to drag about. Unless 10 days' use satisfies you, don't buy.

BREUER'S BALL BEARING TORNADO PORTABLE ELECTRIC BLOWER

Weighs 7 lbs. Connects to any socket. Super powerful—delivers more air with more force. 1-3 h.p. G-E motor. Ball-bearings—no oiling. Lessen fire risks, save repairs, shut-downs. Suction or spraying attachments, if desired.

Guaranteed to do the work where others fail. Costs no more—soon pays for itself. Product of 20 years' electrical manufacturing experience. Write for Free Trial Offer.

BREUER ELEC. MFG. CO., 848 Blackhawk Street, CHICAGO

Greater Power proved! "Tornado" floats rubber ball *twice* as high as other blowers.

An ever widening circle
of POWER PLANTS . . .
use Buffalo Forge equipment
Coast to Coast — in central stations, privately owned plants, hospitals and in every corner of the power plant field, Buffalo equipment meets the ever increasing requirement for *good* fans, be the demand for draft apparatus or ventilating equipment. A closer investigation of the types manufactured and the variety of applications will bring a closer realization of the dollars yet to be saved.
"Buffalo"

"Buffalo"

Buffalo Forge Company

188 Mortimer St., Buffalo, N. Y.

Mechanical Draft Apparatus

for plants of all sizes and any kind of fuel

ENGINEERS

who know good fire brick construction insist on

HYTEMPITE

(Reg. U. S. Pat. Off.)

For Furnace Construction and Maintenance

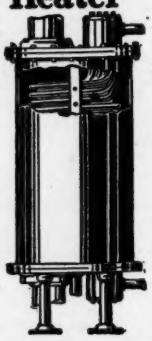
Because Hytempite gives more than a surface bond. It bonds through the entire wall. The thin strong joint resists erosion. Fire Brick bonded with Hytempite gives long service.

Quality guaranteed is 400 lbs. to lay 1000 firebrick.

HYTEMPITE is universally used for laying up fire brick in all types of furnaces, boiler settings, arches, etc. (and when mixed with crushed old fire brick or Ganisand), for monolithic construction, baffles, patches, repairs, special shapes and tile, etc. A copy of "Hytempite in the Power Plant" should be in the hands of every Power Plant Superintendent and Engineer. Ask for yours.

Quigley Furnace Specialties Co., Inc.
26 Cortlandt Street New York City
Stock and Service in Every Industrial Center

Standard Feed Water Heater of the Industrial Field



"NATIONAL" HEATERS

have been on the market longer than any other make. It will pay you to buy the "National" with 44 years of engineering experience behind it. Bulletin 53 sent on request.

The National Pipe Bending Co.
160 River St., New Haven, Conn.

COCHRANE
CLOSED HEATERS

have been designed to secure high heat transmission, to facilitate inspection and cleaning and to eliminate expansion and contraction strains.

COCHRANE CORPORATION
3144 North 17th St. 360-8 Philadelphia, Pa.

GRISCOM-RUSSELL

Evaporators—Feed Water Heaters—Generator Air Coolers—Lubricating Oil Coolers—Steam, Air and Oil Separators—Filters—Strainers—Expansion Joints
Described in bulletins which will be sent on request
THE GRISCOM-RUSSELL COMPANY, Dept. C, 285 Madison Avenue, NEW YORK

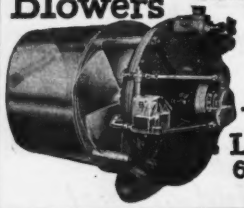
C. H. WHEELER CONDENSING EQUIPMENT

Surface Condensers, Low Level Jet Condensers, Barometric Condensers, with all auxiliaries, including the Radojet Ejector Air Pump
C. H. WHEELER MFG. COMPANY, 19th St., Lehigh and Sedgley Aves., PHILADELPHIA, PA.
"C. H. Wheeler of Philadelphia"

UNIT BLAST FOR STOKERS

Individual Wing Turbine Blowers provide a unit forced draft blast for each stokered boiler. Makes the boiler a unit with its stoker and mechanical draft blower. Central Stations use them for 400 to 500-hp. boilers. Find out why!

Wing Blowers



Ask for Bulletin 87

L. J. Wing Mfg Co.
659-669 Hudson St.
New York, N.Y.

Patterson Hot Water Heaters

Patterson Hot Water Service and Storage Heaters are **guaranteed** to supply all the hot water required, as hot as desired, as quickly as it can be drawn. Operated by exhaust or live steam.

Thousands in use. Backed by 47 years' experience. Made for any service, in any size. Write for catalog.

The Patterson-Kelley Co.
Architects Building, New York

There IS a *Difference*

The RAMTITE ad in the issue of December 1 shows that RAMTITE is the plastic furnace lining backed by successful installation methods. The next RAMTITE ad will appear January 1.

The S. Obermayer Company

2563 W. 18th Street Chicago, Ill.

REFRACTORIES

TO SATISFY EVERY NEED OF POWER PLANT OPERATORS

THERMOLITH

(Reg U.S. PAT OFF.)

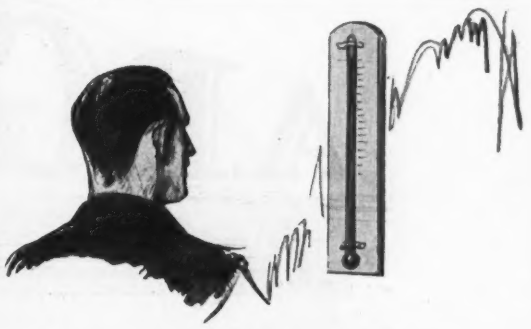
"The High Temperature Cement for Fire Clay Brick"

TRADE MARK

HARBISON-WALKER REFRACTORIES CO.

World's Largest Producers of Refractories

Pittsburgh, Pa. *U.S.A.*



You can go higher with Q.R.Glass

With Q. R. Glass Firebrick it isn't a question of how much can the furnace lining stand—but how high do you want to go.

Originally intended for high temperatures of modern glass furnace practices—Q. R. Glass is now adopted as the standard firebrick for all types of modern boiler furnaces where extremely high temperatures prevail.

When laid with rubbed joints of Queen's Run fireclay, a boiler furnace lining of long lasting durability is the result—a firebrick lining that lasts two to three times as long as ordinary firebrick.

Yes, you can go higher—if you *specify genuine Q. R. Glass*—the firebrick that lasts.

Queen's Run Refractories Co., Inc.

Lock Haven, Penna.

Boston Office, 141 Milk St. New York Office, 15 Park Row
Philadelphia Office, 602 Harrison Bldg.

Plibrico—the superior plastic

gives 2 to 4 times the life of ordinary firebrick. The old reliable. Made entirely of Eastern clays, by world's largest makers. A *flexo-anchor* in each drum. Over 19,000 users. Stocks, engineers, and boiler setting crews in 90 cities. Write Plibrico Jointless Firebrick Co., 1836 Kingsbury St., Chicago.

Free *Write for your copy of the 36-page book, "Cutting Furnace Costs".*

Webers No. 48 Insulating Cement

For high temperature service. Mix with water and apply. It sticks—even to hot surfaces. Great covering capacity makes it economical. Even after long service, can be broken up and used like new material. Write for a liberal sample bag and try it yourself.

INSULATING PRODUCTS CORP., NEW YORK
INSULATING PRODUCTS CO., CHICAGO

1417

American Steel & Wire Company's *American* Wire Rope and AERIAL WIRE ROPE TRAMWAYS

AMERICAN STEEL & WIRE COMPANY

Sales Offices: Chicago, New York, Boston, Cleveland, Worcester, Philadelphia, Pittsburgh, St. Louis, Buffalo, Detroit, Cincinnati, Wilkes-Barre, Baltimore, Kansas City, St. Paul, Minneapolis, Oklahoma City, Atlanta, Birmingham, Memphis, Dallas, Denver, Salt Lake City, U. S. Steel Products Co., San Francisco, Los Angeles, Portland, Seattle.

ADAMANT FIRE BRICK CEMENT

LONGER-LASTING furnace linings are built when the fire brick are laid up with ADAMANT Fire Brick Cement. They are kept in good condition longer by the use of The ADAMANT Gun (Price $25.00) for applying ADAMANT-ADACHROME Mixtures. Send for booklets and complete data.

BOTFIELD Refractories Co.
776 S. Swanson St.
Philadelphia, Pa.
Distributors in All Cities

A.P. GREEN

KRUZITE MIZZOU

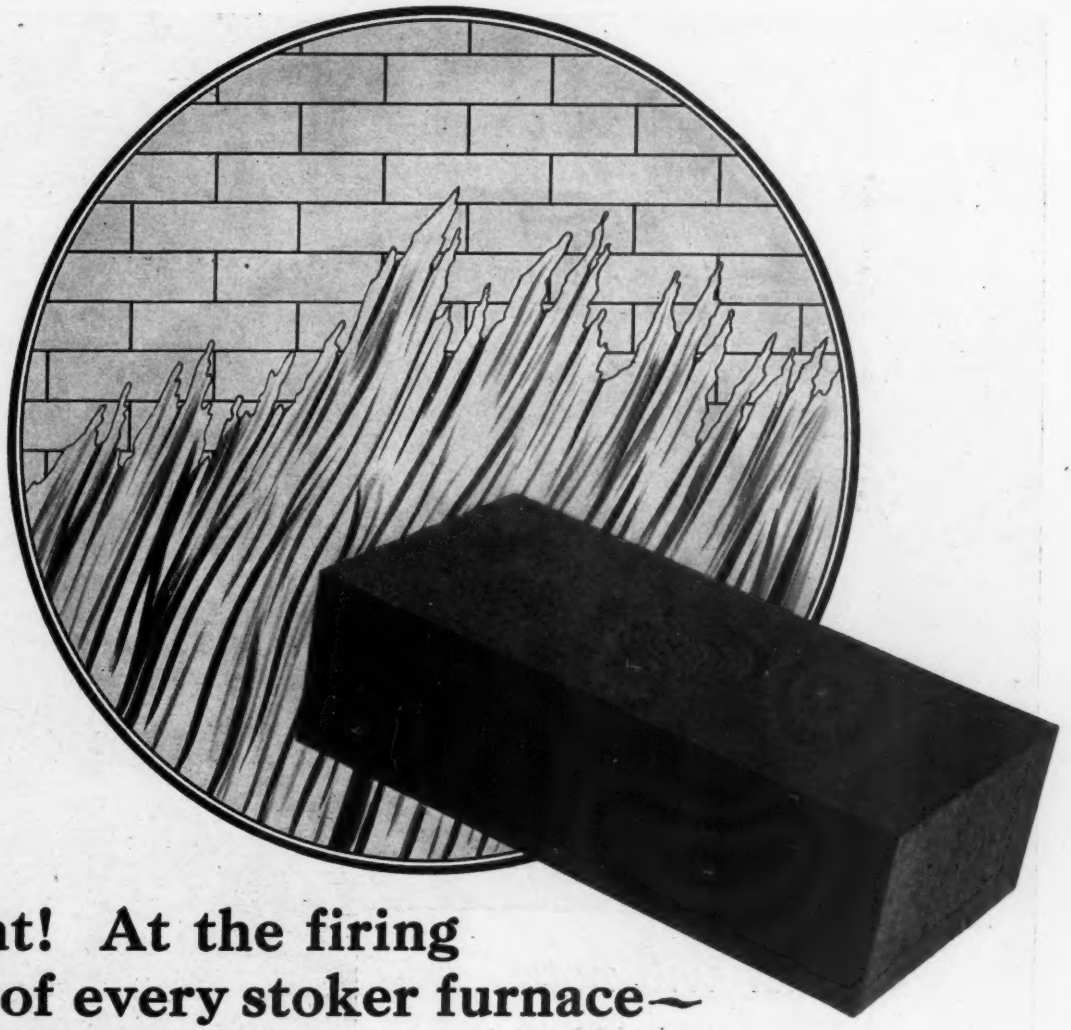
Super Refractories

For extreme service, use KRUZITE or MIZZOU. Both are A. P. Green High-Alumina (Diaspore) Fire Brick • • • KRUZITE has a dense structure—and remarkable load bearing qualities under heat. Especially recommended where severe, destructive actions are present • • • MIZZOU has a more open texture. It, too, has high resistance to heat, and is very desirable for fluctuating temperatures and heavy loads.

Write us about your "super" requirements. Our engineers will recommend the proper refractory.

A.P. GREEN FIRE BRICK CO.
MEXICO, MISSOURI, U. S. A.

"The Story of Kruzite and Mizzou Super Refractories" is an interesting booklet. A copy will be sent on request



Right! At the firing line of every stoker furnace—

Crystolon Brick (silicon carbide) are a dependable barrier against frequent take downs of modern boiler furnace linings.

Immune to the highest furnace temperature and free from objectionable shrinkage and spalling.

Their dense structure prevents slag penetration. Clinkers will not fuse to Crystolon Brick.

Last but not least—their resistance to abrasion by the constantly surging fuel bed of mechanical stokers, is a feature that insures endurance.

Crystolon Brick are a lasting economy in every stoker furnace.

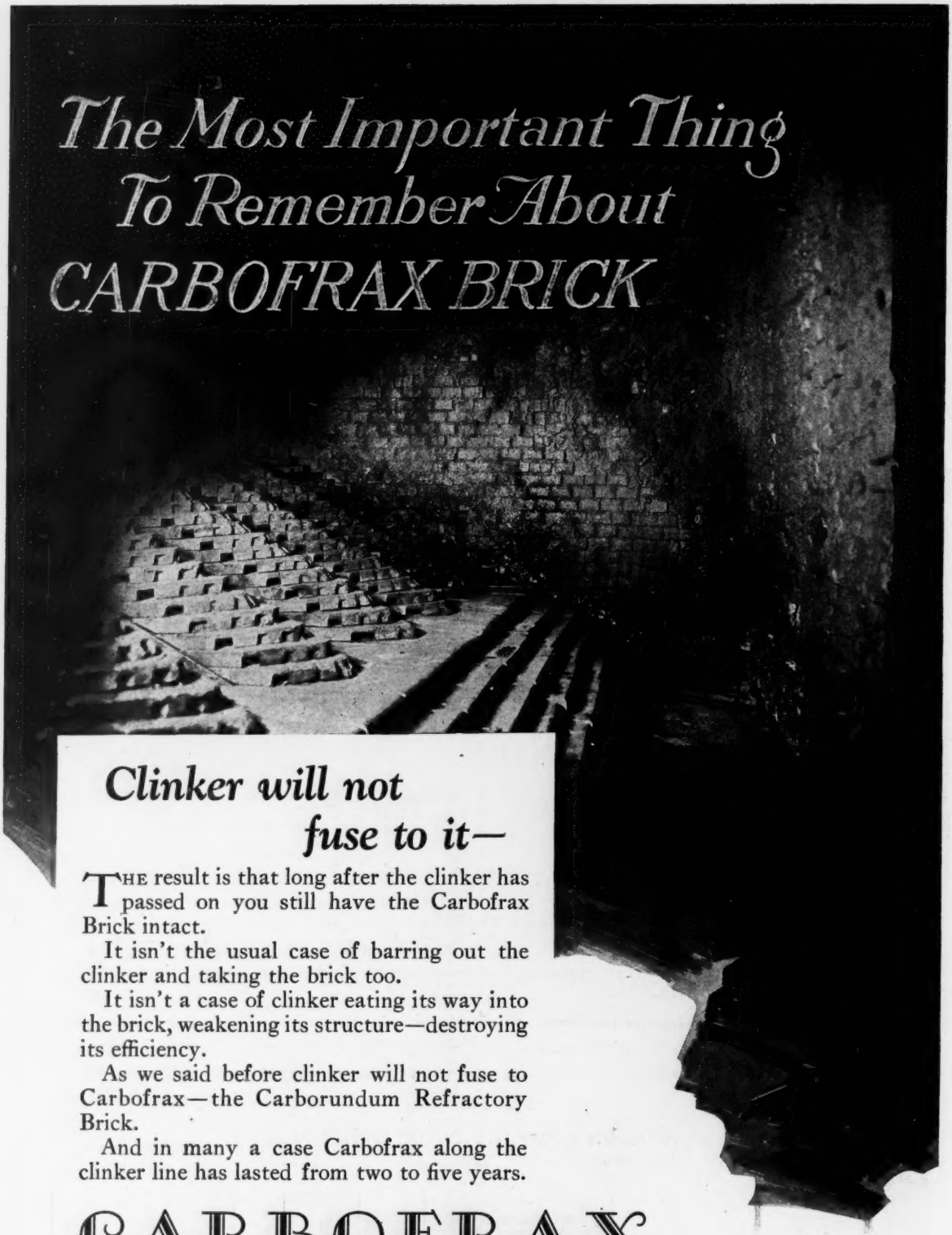
Write us for booklet

NORTON COMPANY, WORCESTER, MASS.
New York Chicago Cleveland

NORTON
REFRACTORIES

R-

The Most Important Thing To Remember About CARBOFRAX BRICK



Clinker will not fuse to it—

THE result is that long after the clinker has passed on you still have the Carbofrax Brick intact.

It isn't the usual case of barring out the clinker and taking the brick too.

It isn't a case of clinker eating its way into the brick, weakening its structure—destroying its efficiency.

As we said before clinker will not fuse to Carbofrax—the Carborundum Refractory Brick.

And in many a case Carbofrax along the clinker line has lasted from two to five years.

CARBOFRAX
THE CARBORUNDUM REFRACTORY
REG. U. S. PAT. OFF.

THE CARBORUNDUM COMPANY, PERTH AMBOY, N. J.

Christy Firebrick Company, St. Louis, Mo.
Pacific Abrasive Supply Co., San Francisco and Los Angeles
Harrison & Company, Salt Lake City, Utah
Williams & Wilson, Ltd., Montreal

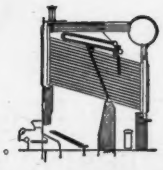
Carborundum is the Registered Trade Name used by The Carborundum Company for Silicon Carbide. This Trade Mark is the exclusive property of The Carborundum Company.

A new, informative Catalog on Boiler Baffling—

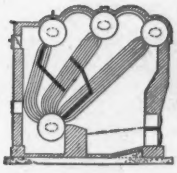
Just off the press—it contains the latest information on the efficient baffling of both horizontal and vertical water tube boilers

The

Enco Baffle Book

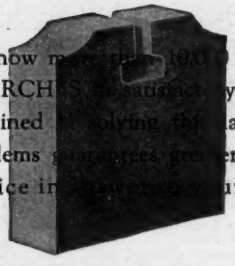


Send for your copy
NOW!



The Engineer Company, 17 Battery Place, New York

There are now more than 1000 installations of DETRICK ARCHES in satisfactory service. The experience gained in solving this large number of furnace problems guarantees greater efficiency and lasting service in connection with your own furnace problems.



M. H. Detrick Company
Chicago
140 S. Dearborn Street
New York: 50 Church St. Pittsburgh: Empire Bldg.

American

Brick Chimneys
Boiler Settings

American Chimney Corporation
147 Fourth Avenue
New York, N. Y.
Branches:
Boston Cleveland Philadelphia
Chicago Detroit

FOR all power plant and industrial requirements.

Designed and erected by men of 27 years' experience.

Let us solve your chimney problems. No obligation for sketch and cost estimate. Write for new catalog.

Keep your boilers at maximum capacity

You can easily keep your boilers at maximum capacity by making permanent patches or recoating boiler furnace linings with the

CEMENT-GUN (TRADE MARK)

Only machine that handles material in dry state. Make repairs while boiler is being cleaned.

Send coupon for complete particulars.

CEMENT-GUN COMPANY, INC.
ALLENTOWN, PENNA.

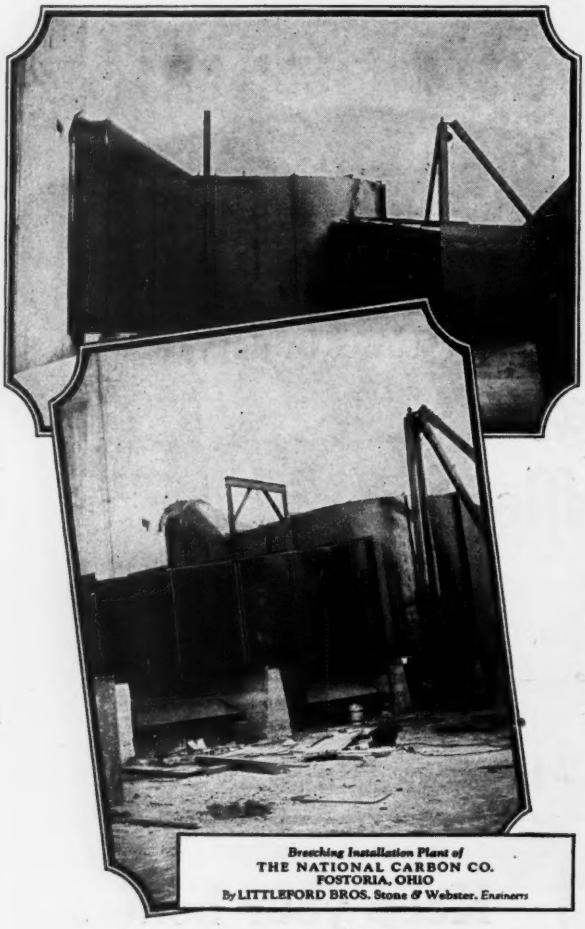
CEMENT-GUN CO., INC.
Allentown. Penna.

Gentlemen:
Please send us full information regarding the many uses of the "Cement-Gun" around the boiler plant.

Name .....

Address .....

We would also be interested in having your Contract Department give us quotations on lining bunkers and breechings, or for constructing "Gunite" Stacks around old steel stacks.



Breeching Installation Plant of
THE NATIONAL CARBON CO.
FOSTORIA, OHIO
By LITTLEFORD BROS. Stone & Webster, Engineers

LITTLEFORD CONSTRUCTION *WINS AGAIN!*

Engineers for the National Carbon Co., Fostoria, Ohio, plant, together with those of Stone and Webster chose Littleford Breeching Construction on account of its Tightness and Durability. Littleford breechings and ducts are made with flanged corner connections, seams riveted on 8-inch centers, and electrically welded absolutely tight in field. Expansion and contraction are taken care of by the Littleford Bellows Type Expansion Joint.

Your blueprints will bring an interesting quotation.

LITTLEFORD

Bellows Type

EXPANSION JOINT

LITTLEFORD BROS.

440 East Pearl Street **Cincinnati, Ohio**

Established 1884

THERMIX AIR HEATER and STREAM LINE STACK

Thermix is a plate-type Heater guaranteed to effect a big saving by recovering heat from the flue gas and transferring it to air for boilers or for industrial use.

Stream Line Stack is a stack and induced draft fan in one unit. Reduces power lost due to bends and turns. Low initial cost.

Write for Catalog

PRAT-DANIEL CORPORATION

101 Park Ave. **New York, N. Y.**

"For reference see: Sweet's Engineering Catalog or A. S. M. E. Condensed Catalog."

CHIMNEYS

Perforated Radial Brick

RUST

Reinforced Concrete

BOILER SETTINGS

COMPLETE POWER PLANTS

THE RUST ENGINEERING CO.

PITTSBURGH, PA.

NEW YORK - - WASHINGTON - - BIRMINGHAM

"STEEL MIXTURE"

Furnace Linings and Arches

Complete Boiler Settings
Veneer and Air-Cooled Linings
Boiler Door Arches—Fire-Box Blocks
Flat Suspended Furnace Arches
Back Arches for H. R. T. Boilers
Blow-Off Pipe Protectors
Standard Fire Brick
High-Temperature Cement

Write for Booklet No. 29

McLEOD & HENRY CO.
29 Monroe Street, Troy, N.Y.
Branch Offices: New York - Boston - Cleveland - Detroit

REG. U.S. PAT. OFF.

Everything's in Bulletin "E"

Bulletin "E" explains why the BECO is the only baffle that has positive expansion joints. The BECO eliminates tiling. It is NOT monolithic. Lasts indefinitely. Write for this bulletin which explains everything in detail.

this simple corrugation does the trick

BOILER ENGINEERING CO.
931 Federal Trust Bldg., Newark, N. J.
Without any obligation to me whatever please send Bulletin "E" to:
Name .....
Firm .....
Address .....

No bridge wall expense here!

THIS unretouched photograph shows a Foster Water Back after 9,438 hours of service in the furnace of a stoker-fired Bigelow-Hornsby Boiler.

The photograph clearly shows that the water back was in excellent condition, without material slag accumulation and with no signs of deterioration.

Elimination of bridge wall maintenance is only one of the many benefits secured by replacing troublesome brickwork with a Foster Water Back. These durable metallic surfaces, connected into the boiler circulation, increase the heating surface and boiler capacity. The operator of this water back has written us: "They enable us to run our boilers at a higher rating and for a longer time than was possible with the brick wall. The fires are much easier cleaned, and there is less avalanching of the fire when cleaning, consequently less combustible in the ash under similar conditions."

Write for Catalog

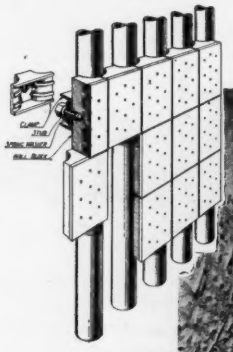
FOSTER WHEELER CORP.
165 Broadway, New York
Branches in principal cities

FOSTER WHEELER

AERO UNIT COAL PULVERIZERS
AIR HEATERS CENTRIFUGAL PUMPS
CONDENSERS COOLING TOWERS
ECONOMIZERS EVAPORATORS
EXPANSION JOINTS FEED WATER HEATERS

FRACTIONATING TOWERS HEAT EXCHANGERS
STEAM JET AIR PUMPS SUPERHEATERS
TUBE STILLS VACUUM PUMPS
WATER COOLED FURNACE SURFACES
BRASS AND COPPER TUBING AND PIPE

AN INVESTMENT



FOR—

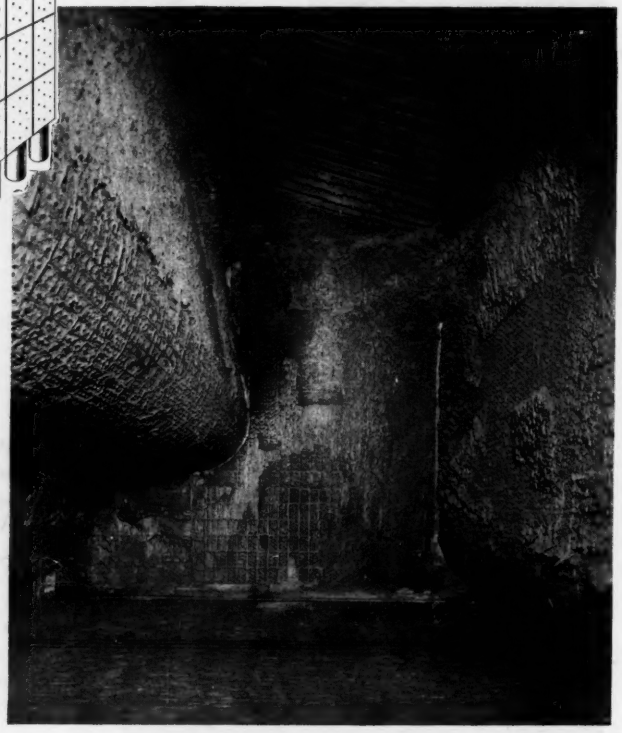
CAPACITY

SERVICE

EFFICIENCY

DURABILITY

SAFETY



View showing interior of traveling grate stoker fired boiler furnace, equipped on both sides, arches and bridge wall with Bailey Furnace Wall construction. This photograph was taken after eight months of service.

BAILEY WALLS

The Bailey Furnace Wall is adapted to practically all types of boiler furnaces and fuels.

Permits smokeless combustion at all rates of operation.

The refractory faced construction makes possible a wide range of combustion rates as well as highest efficiencies.

Furnace maintenance costs and boiler outages are reduced to minimum amounts.

Typical Installations

PULVERIZED COAL FIRING

Calumet Station, Commonwealth Edison Co., Chicago. Sargent & Lundy, Engineers.
Chas. R. Huntley Station, Buffalo General Electric Co., Buffalo, N. Y.
Ashley Street Station, Union Electric Light & Power Co., St. Louis, Mo. McClellan & Junkersfeld, Inc., Engineers.

STOKER FIRING

Richmond Station, Philadelphia Electric Co., Philadelphia.
Crawford Ave. Station, Commonwealth Edison Co., Chicago. Sargent & Lundy, Engineers.
Saxton Station, Penn Central Light & Power Co., Saxton, Penna. Day & Zimmermann, Inc., Engineers.
Western United Gas & Electric Co., Aurora, Ill. Stone & Webster, Inc., Engineers.
Chester Station, Philadelphia Electric Co., Chester, Penna.

OIL AND GAS FIRING

San Diego Consolidated Gas & Electric Co., San Diego, Calif. Byllesby Engineering & Management Corp., Engineers.
Long Beach Steam Plant No. 2, Southern California Edison Co., Long Beach, Calif. Stone & Webster, Inc., Engineers.
Neches Station, Gulf States Utilities Co., Beaumont, Texas. Stone & Webster, Inc., Engineers.

FULLER LEHIGH COMPANY

[A Babcock & Wilcox Organization]

FULLERTON----PENNSYLVANIA

Gold Medal awarded to Connery & Company at the Sesqui-Centennial, Philadelphia, 1926.

Connery reviews list of installations at the close of 1927

Over a Million Horsepower now equipped with Connery's Construction:

Companies

Public Service Co.
Penn Central Power Co.
United Illuminating Co.
Western Electric Co.
Monongahela West Penn Pr. Co.
Metropolitan Electric Co.
Standard Oil Co.
Eastman Kodak Co.
Michelin Tire Co.
Semet Solvay Co.
Eastern Conn. Power Co.
Phila. Suburban Gas Co.
Virginian Railway Co.
Mystic Iron Works
Brooklyn Edison Co.
Crouse-Hinds Co.
Exeter Power Co.
Ohio Power Co.
New York Steam Co.
Adirondack Light & Power Co.
Federal Reserve Bank
Kieckhefer Container Co.
Eastern High School
Lehigh Industrial Power Co.
Kentucky & W. Va. Power Co.
Memphis Gas & Electric Co.
Luzerne County Electric Co.
New Haven Gas Light Co.
Penna. Water & Power Co.
Illinois Power & Light Co.
Franklin Sugar Refining Co.
Standard Underground Cable Co.
Mexican Petroleum Co.
Refining & Molasses Co.
Wm. H. McCahan Sugar
The Wilkes-Barre Co.
Joseph Campbell Co.
American Gas & Electric Co.
Louisiana Power Co.
Los Angeles Gas & Electric Co.
Columbia Power Co.
Houston Light & Power Co.
Anaconda Copper Mining Co.
Duquesne Power Co.

Engineers

Stone & Webster, Inc.
J. G. White Eng. Co.
Harry H. Hope Eng. Co.
McClintock & Craig
E. L. Phillips Co.
Day & Zimmerman
McClelland & Junkersfeld
Wescott & Mapes
Sargent & Lundy
Sanderson & Porter
Chas. T. Main, Inc.
Phoenix Utility Co.
Freyn Engineering Co.
Ford, Bacon & Davis
W. S. Barstow Management Assn.
Gibbs & Hill
D. P. Robinson & Co.

With an ever-increasing number of users, Connery products are today serving leading central stations and industrial plants throughout the country. The high reputation of this construction for permanency, strength and flexibility has become an established fact. Fifty years of experience is back of this Improved Construction.

Connery Improved Expansion Stiffener, with its ample provision for maximum contraction and expansion, without sliding joints, will not warp, buckle, or collapse, and insures greater economy.

The electrically welded corners and laps make Connery's Construction gas-tight and moisture-proof. No points for corrosion to attack.

Avoid trouble on Breeching, Uptakes, Air Preheater Ducts by specifying

Connery Construction that Costs No More than the Ordinary Kind

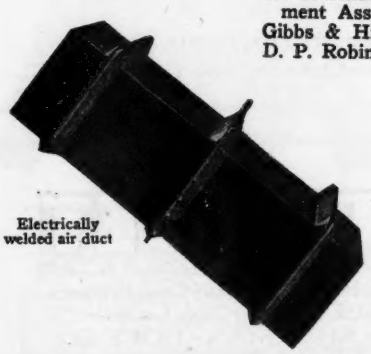
Yet Connery's gives reliable service that makes it the demand of leading engineers and power companies everywhere.

Write for descriptive bulletin and full information on Expansion Stiffener, Expansion Stack Connection, Patented Adjustable Covering and Air-Cooled Damper.

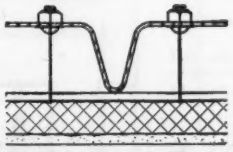
Home Office and Plant

CONNERY AND COMPANY, Inc.

Fifty years' experience. Established 1877.
4000 North Second St., Philadelphia, Pa.
New York Office

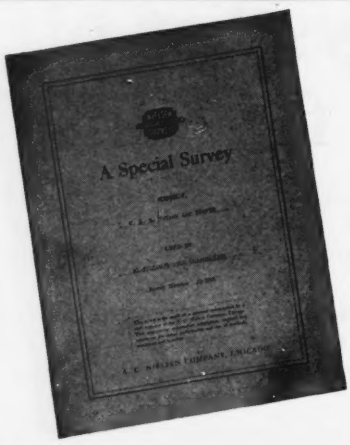


Electrically welded air duct



Connery's Patented Clip for Adjustable Covering

We recommend
TRUFILM
HEAT RESISTING PAINT
Manufactured by
Allen Varnish Co., Philadelphia, Pa.



Send for Bulletin No. 83

Only One Operation with the W-S-M *Revolving Car Dumper*

Unloading coal by hand is slow, tedious and involves an unnecessary expense that would soon pay for a scientific car dumper.

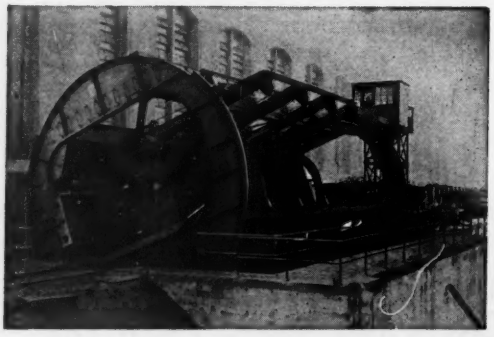
W-S-M Revolving Car Dumpers are economical and eliminate this expense.

Faster, too, dumping 120-ton capacity cars continuously at an average of one every two to three minutes.

Built in lengths of 30, 40, 50 and 60 ft. for handling cars from 6 ft. 6 in. to 13 ft. high and from 9 ft. to 10 ft. 9 in. wide and loaded capacities up to 320,000 lb. gross weight.

RECENT PURCHASERS

The Koppers Co. for Bethlehem Steel Co.
The Koppers Co. for Commonwealth Edison Co. (2 plants)
By-Products Coke Corp.
Utah Copper Co. (2 machines)
Cleveland Electric Illuminating Co.
Chile Exploration Co. (2 machines)
The Anglo-Chilean Consolid. Nitrate Corp.
The American Gas & Elec. Co.
Florida Portland Cement Co.
Semet-Solvay Company
Indiana & Michigan Electric Co.
Standard Oil Co., Whiting, Ind.
Western Maryland Railway Co.
Anaconda Copper Mining Co.



The Wellman-Seaver-Morgan Co.

7003 Central Ave., Cleveland, O., U. S. A.
New York at 522 Fifth Ave.—Birmingham at 1101 American Trust Bldg.
In Canada—"Canadian Wellman-Seaver-Morgan Co., Limited," 307 Reford Bldg., Toronto—808 Drummond Bldg., Montreal

Burn Cheaper Fuels Economically

Neemes Grates are specially designed to burn the smaller and cheaper sizes of anthracite, any size of bituminous coal, slack, lignite, tanbark, and mixtures of coals and sawdust, and to burn these fuels without waste.

Send for bulletin

Neemes Foundry, Inc., Troy, N. Y.

NEEMES

Shaking and Dumping

GRATES

GIRTANNER

CONVEYORS

Ash, Soot, Combustion Ash and other Abrasive Materials Conveyed by

Air, Water or Steam

Also Ash Pit and Furnace Doors

New Catalogue No. 38

GIRTANNER ENGINEERING CORP.
122 Greenwich Street, New York City

HYDROJET

ASH SLUICING SYSTEMS

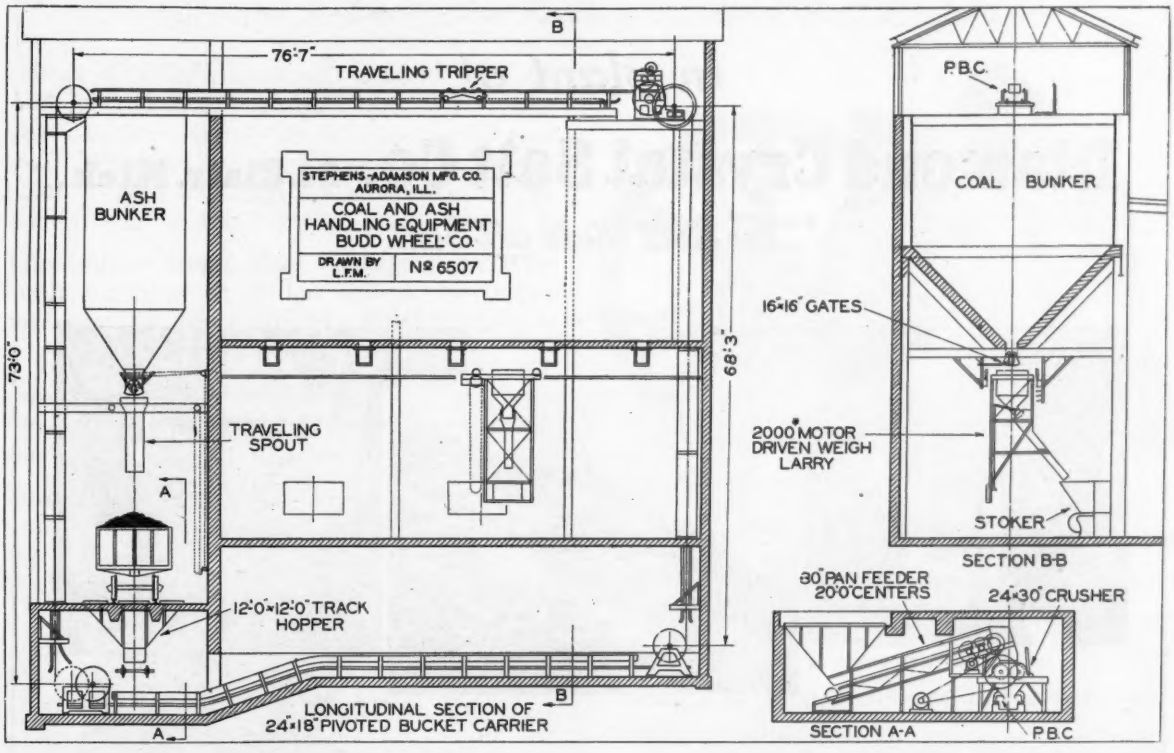
Cast Iron Ash Hoppers ~ Tanks ~ Coal Bunkers
Water Collecting Ash Gates

ALLEN-SHERMAN-HOFF CO.
229 S. 15TH ST. PHILADELPHIA

Write for Catalogs

S-A PIVOTED BUCKET CARRIER

COAL AND ASH HANDLING AT ITS BEST

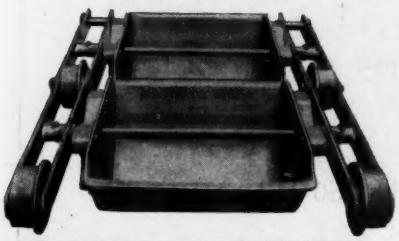


The drawing shows the arrangement of the coal and ash handling machinery at the Budd Wheel Co. plant.

Trace the flow of coal from the railroad cars, through the crusher, up and into the overhead bunker and to each boiler via the traveling weigh larry.

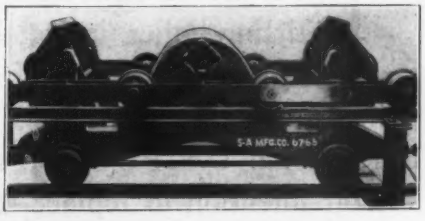
Ashes, however, are collected in small industrial cars and elevated to an overhead ash bunker by the same Pivoted Bucket Carrier which handles the coal.

S-A Pivoted Bucket Carriers operate quietly and efficiently, giving years of constant service in power plant installations. Equipments have been in operation for periods of years and present repeated evidence of sound design and careful workmanship.



The buckets are swung pivotally between two strands of long pitch steel bushed roller chain. The lips over-lap to prevent spillage between the buckets.

Write for Bulletin 150 containing a complete, illustrated article pertaining to this coal and ash handling equipment.



TURNOVER DUMP BUCKET MAKES COMPLETE REVOLUTION IN DISCHARGING

For unloading a bucket the S-A Tripper has a definite advantage. The bucket cams are symmetrical and reversible.

DESIGNERS AND BUILDERS OF LABOR SAVING MATERIAL HANDLING MACHINERY

STEPHENS-ADAMSON MFG. CO. Main Offices, Aurora, Ill.
Branch Offices in Principal Cities

AURORA S-A MFG.CO ILLINOIS

STEPHENS-ADAMSON

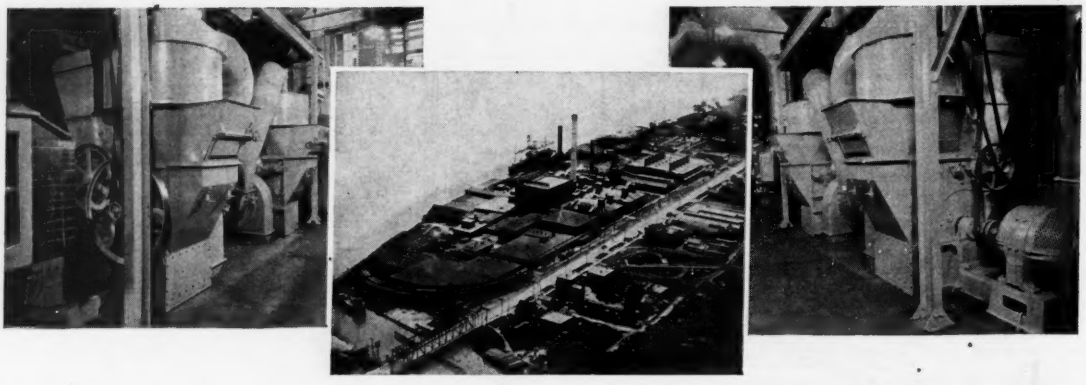
PLANTS: AURORA, ILLINOIS — LOS ANGELES, CALIFORNIA — BELLEVILLE, ONTARIO

UNIPULVO
UNIT PULVERIZER

in plant of

Diamond Crystal Salt Co. St. Clair, Mich.

"The Salt that's all Salt."



TWO UNIPULVOS were installed under an existing 905 HP. Stirling boiler, in October, 1926. After a year's operation, during which period efficiencies from 79 to 80 per cent became daily practice, in spite of limited furnace conditions, this Company has ordered two additional UNIPULVOS for equipping its second boiler unit. It is their intention to replace stokers under a THIRD boiler, with Unit Pulverizers, as rapidly as possible. UNIPULVOS operate with remarkably low up-keep and power consumption.

THERE IS A UNIPULVO FOR EVERY BOILER—150 HP. AND UP

THE STRONG-SCOTT MFG. CO.

MINNEAPOLIS, MINNESOTA

IN CANADA:

THE STRONG-SCOTT MFG. CO., LTD.

WINNIPEG

TORONTO—50 Front St. East

DISTRICT OFFICES

BOSTON, Chamber of Com'ce
NEW YORK, 342 Madison Av.
PHILA., Mach'y Sales, Bourse
BUFFALO, Prudential Bldg.
CLEVELAND, National Bldg.
DETROIT, Donovan Bldg.
CHICAGO, Monadnock Bldg.
GRAND RAPIDS, Michigan Trust Bldg.
ST. LOUIS, Syndicate Trust
PITTSBURGH, Bessemer Bldg.
KANSAS CITY, Sterling Bldg.

JEFFREY SINGLE ROLL CRUSHERS

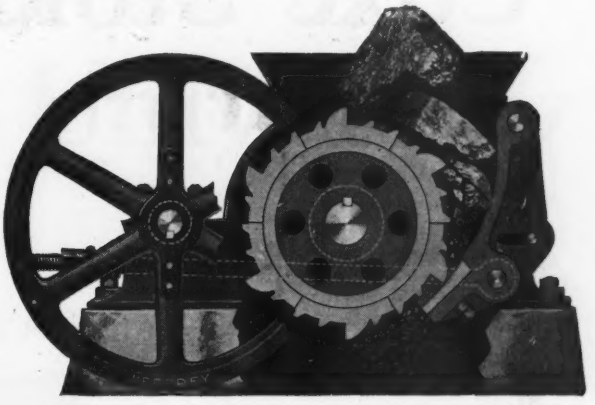
for Reducing Coal in One Operation to Proper Sizes for Hand Firing, Automatic Stokers, or for Feeding Powdered Fuel Equipments

Jeffrey Crushers form an integral part of modern coal handling installations. They insure a constant supply of stoker or small size coal. With a Jeffrey Crusher, the power plant is able to crush its own coal to any desired size at low cost.

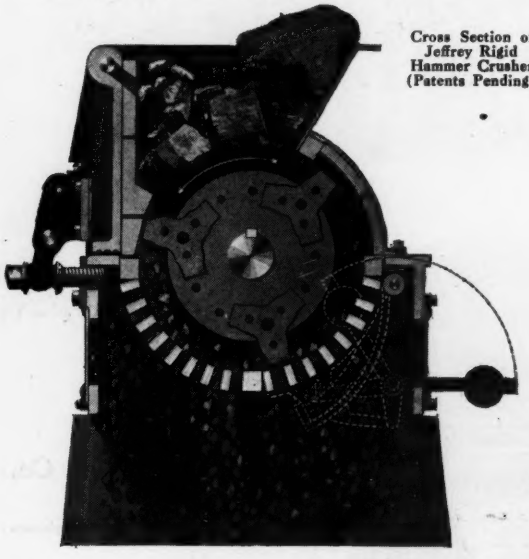
The Jeffrey Single Roll Crusher is that reliable machine which has solved the stoker coal problem for more than 4000 users.

A uniform product of 1¼-in. and under for automatic stokers, and 6-in. and under for hand firing, is readily obtainable with this machine.

Built in five sizes with capacities ranging from 25 tons to 1100 tons per hour, depending upon the hardness of coal and size of product required.



Cross Section of Jeffrey Single Roll Crusher (Patented)



Cross Section of Jeffrey Rigid Hammer Crusher (Patents Pending)

The Jeffrey Rigid Hammer Crusher

is a new single-roll type of crusher that will reduce coal to smaller uniform pieces with a smaller amount of fines than has been produced heretofore with coal crushers.

It is especially recommended where a uniform product 1 inch or smaller down to ¼ inch is desired.

With an assortment of sizes, a complete range of products and capacities is available.

Tell us what your crushing requirements are. There's a Jeffrey machine to meet them.

The Jeffrey Manufacturing Company
905-99 North Fourth St., Columbus, Ohio

New York, Buffalo · Rochester, N.Y., Philadelphia · Pittsburgh, Scranton, Pa. · Boston, Cincinnati · Cleveland, Detroit · Chicago, Charleston, W. Va. · Milwaukee, St. Louis · Denver, Salt Lake City · Los Angeles, Birmingham · Charlotte, N. C., Montreal

50 YEARS OF SERVICE TO INDUSTRY

JEFFREY
MATERIAL HANDLING EQUIPMENT

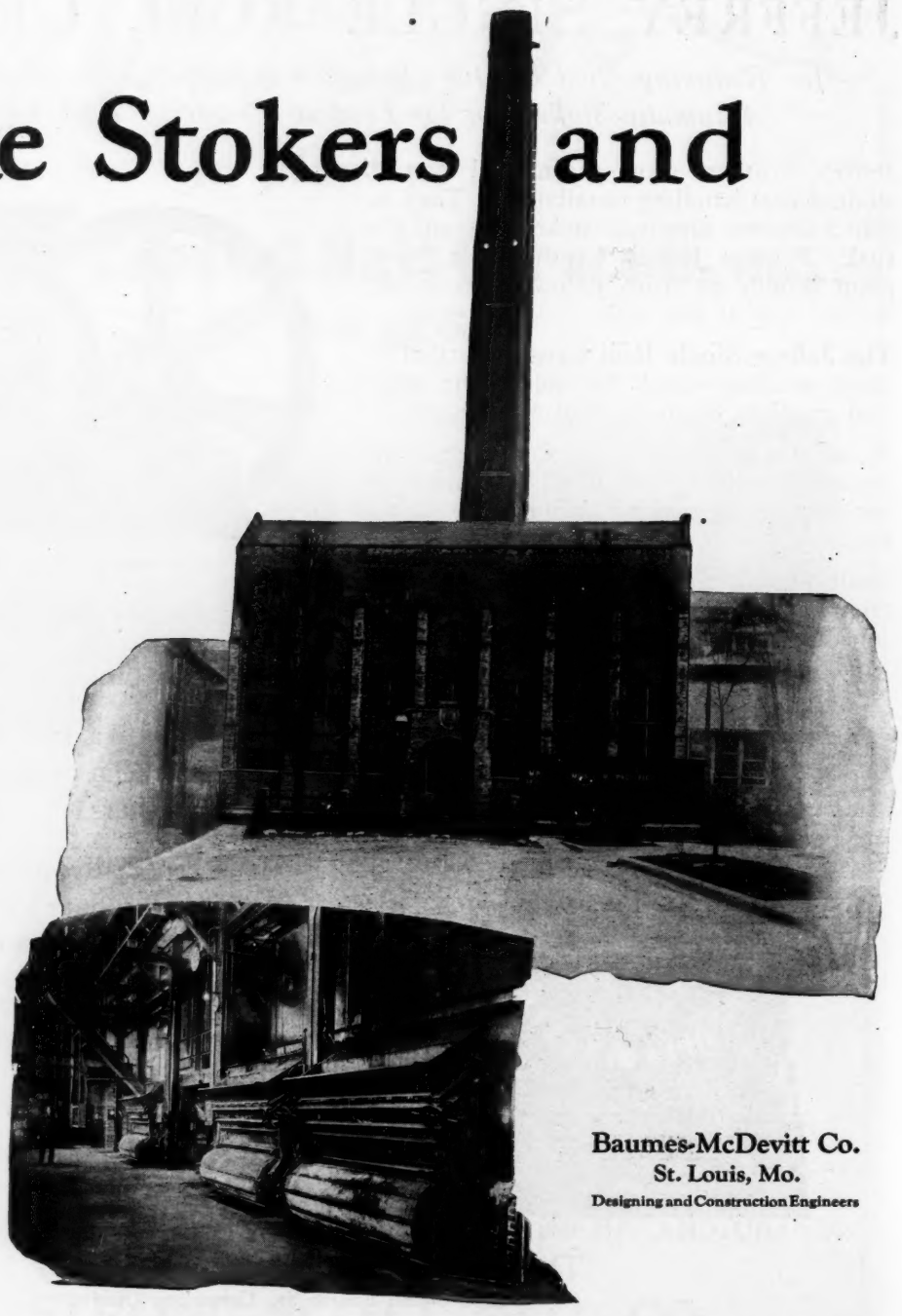
Jeffrey Products

Elevators—Conveyors
Portable Loaders
Coal and Ashes Handling Equipment
Skip Hoists
Chains and Attachments
Sprocket Wheels—Gears
Crushers—Pulverizers
Sand and Gravel Handling, Washing and Screening Equipment
Locomotives
Coal Mine Equipment
Tipple Equipment
Ventilation Fans

Coxe Stokers and

INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

Fuel Burning and Steam Generating Equipment
Lopulco Storage System (Pulverized Fuel)
Lopulco Unit System (Pulverized Fuel)
Raymond Pulverizing Mill
C-E Fin Furnace
C-E Air Preheater
Frederick Multiple Retort Stoker
Type E Stoker
Type K Stoker
Type H Stoker
Coxe Stoker
Green Natural Draft Stoker
Green Forced Draft Stoker
C-E Ash Conveyor
Combustion Steam Generators
Heine Boilers
Ladd Boilers



Baumes-McDevitt Co.
St. Louis, Mo.
Designing and Construction Engineers

Combustion
International Combustion Building Corpor

A SUBSIDIARY OF INTERNATIONAL

Heine Boilers at Washington University

THE power plant at Washington University, St. Louis, is a splendid example of a modern steam generating station of medium size.

Architecturally, it was designed to add beauty and dignity to the University grounds. Mechanically, nothing has been spared to make its operation as efficient and clean as possible.

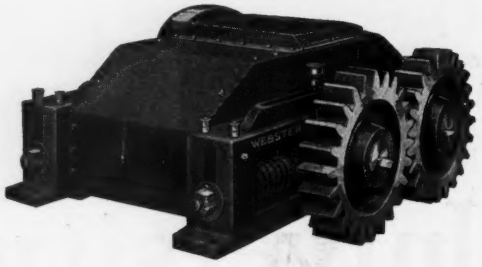
Coxe stokers, burning low grade Illinois coal assure low fuel costs.

Heine cross drum boilers assure dependable and efficient production of steam.

This plant is typical of scores of modern, well designed and well operated power plants where Combustion Engineering products have been selected after careful comparison of operating costs.

Engineering
ation 200 Madison Ave (35th to 36th St.) New York

COMBUSTION ENGINEERING CORPORATION



Webster Coal Crushers

Webster coal crushers in single and double roll types for reducing run of mine coal to stoker sizes. Ruggedly built and well designed to meet every requirement in hard daily service. Built in various sizes with capacities 30 to 200 tons per hour.

We also make a complete line of Coal and Ash Handling Equipment.

Send for Coal Crusher Catalogue

The Webster Mfg. Company
1856 N. Kostner Ave. Chicago
Offices in Principal Cities

"PENNSYLVANIA" *STEELBUILT*
COAL BREAKERS AND CLEANERS (Bradford Type)
KING COAL MILLS ARMORFRAME CRUSHERS

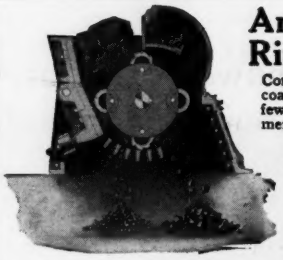
"Pennsylvania" STEELBUILT Coal Preparation Machinery offers engineers and operators a wide selection of types and sizes, specialized for heavy, continuous service in Central Stations, Gas Works and Industrial Power Plants.

POSITIVE TRAMP IRON PROTECTION
UNBREAKABLE STEEL CONSTRUCTION

Put your coal preparation problems up to us.

PENNSYLVANIA CRUSHER COMPANY

General Offices: Liberty Trust Bldg., Philadelphia
New York Pittsburgh Chicago London



An IMPROVED Ring Coal Crusher

Combines more uniformly crushed coal, small power consumption and few repairs with patented adjustments to take up wear, patented metal trap and split cover for quick adjustments and repairs. Eight sizes.

Williams Patent Crusher & Pulverizer Co.
700 St. Louis Ave., St. Louis, Mo.
Chicago New York
37 W. Van Buren St. 15 Park Row
San Francisco
415 5th Street

Williams
ORIGINAL PATENTEES AND WORLD'S LARGEST BUILDERS OF HAMMERMILLS
PATENT CRUSHERS GRINDERS SHREDDERS

The Taylor Stoker

The Simplest, most Efficient, most Economic System of Combustion for Central Stations and Industrial Power Plants

AMERICAN ENGINEERING COMPANY
Kensington Station, PHILADELPHIA, PA.

Canadian Sales and Service by AFFILIATED ENGINEERING COMPANIES, Ltd.
Head Office: Southam Bldg., MONTREAL, QUE.

Get the Most out of your Refuse Fuels

Complete furnace equipment, including feed device for automatically feeding refuse fuel into the furnace. Burns refuse alone or with coal or coal alone.

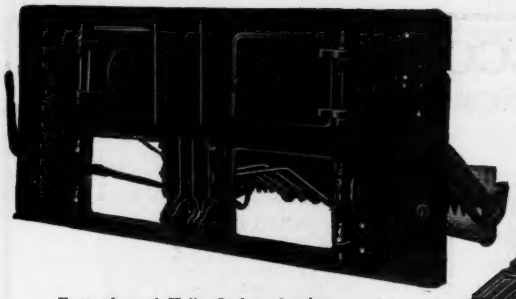
THE M. A. HOFFT CO.
816 Washington Avenue, Indianapolis, Ind.

NATIONAL STOKERS — NATIONAL ARCHES

for combustion efficiency

of low grade, inexpensive coals and for low upkeep costs, write to the Laclede Stoker Co., 4438 Hunt Ave., St. Louis, Mo., for particulars regarding the

Laclede *Chain Grate* **Stoker**



Font view of Kelly Stoker showing levers which control the grate bars and the dumping plates. Fire doors are opened only to put on coal.

Normal position with all grate bars down. Fuel cokes on bed plate at front, and then is moved down the incline to dumping plate at rear.

Act Now and you can Review Next Year's operation and find fuel bills cut 10 to 15%

INSTALL Kelly Hand Stokers right under your present boilers and burn cheaper grades of coal. With these stokers, you can burn either cheap or high grades with a high rate of combustion, and end loss due to waste of combustible in the ash pit.

Designed and built by engineers of 40 years' experience, these stokers are easily operated by outside levers. They have Kelly Heat-Resistant Castings.

Save from 10 to 15 per cent on your fuel bills for your plant as hundreds of others are doing throughout the country.

Write for full information that you may know the many points of economy of Kelly Stokers.

The Kelly Foundry & Machine Co.

617 Ninth St. **Goshen, Ind.**

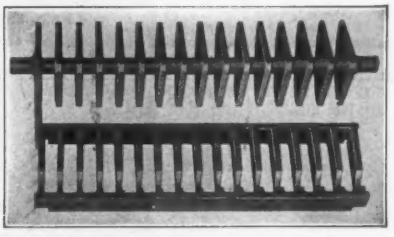
POWER PLANT ENGINEERS

New York Office: 53 Park Place — **Established 1887** — **Chicago Office:** 111 W. Washington St.

KELLY IMPROVED HAND STOKERS

Easy to install

Easy to operate



Close up view shows perfect meshing of the movable and stationary bars. The shearing action keeps the surface clean without slicing. The air openings are not increased when the grate bars are in operation.

Alternate rows of grate bars raised. Each outside lever controls three bars on one side. Separate levers operate the dump plates.

WHEN YOU BUY KELLY STOKERS-GRATES GOSHEN IND. YOU BUY RESULTS

THE BABCOCK & WILCOX COMPANY

85 LIBERTY STREET, NEW YORK

Builders since 1868 of Water Tube Boilers of continuing reliability

BRANCH OFFICES

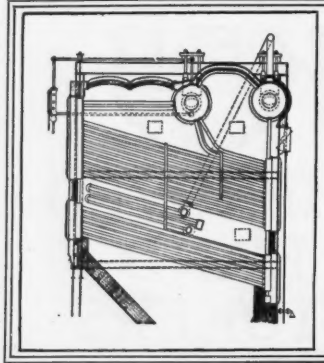
BOSTON, 80 Federal Street
PHILADELPHIA, Packard Building
PITTSBURGH, Farmers Deposit Bank Building
CLEVELAND, Guardian Building
CHICAGO, Marquette Building
CINCINNATI, Traction Building
ATLANTA, Candler Building
PHOENIX, ARIZ., Heard Building
DALLAS, TEXAS, Magnolia Building
HONOLULU, H. T., Castle & Cooke Building
PORTLAND, ORE., Gasco Building

Works
Bayonne, N. J.
Barberton, Ohio

Makers of Steam Superheaters since 1898 and of Chain Grate Stokers since 1893

BRANCH OFFICES

DETROIT, Ford Building
NEW ORLEANS, 344 Camp Street
HOUSTON, TEXAS, Electric Building
DENVER, 444 Seventeenth Street
SALT LAKE CITY, Kearns Building
SAN FRANCISCO, Sheldon Building
LOS ANGELES, Central Building
SEATTLE, L. C. Smith Building
HAVANA, CUBA, Calle de Aguiar 104
SAN JUAN, PORTO RICO, Royal Bank Building



The Connelly Sectional Heater CROSS-DRUM Boiler—

PRODUCES the same important first few degrees of superheat that you get from the famous Connelly bent-tube boilers. Built with either one or two cross-drums and can be manufactured in units up to 35,000 sq. ft. of heating surface and for steam pressures up to 1200 lbs.

Catalogs on either type of Connelly boiler will be sent promptly. Write

50 Years of Knowing how!

The CONNELLY BOILER COMPANY · *Cleveland, Ohio*

SUPERHEATERS

ELESCO

Peoples Gas Building Chicago
Montreal Canada
Union Trust Building Pittsburgh
London Paris

THE SUPERHEATER COMPANY
17 EAST 42nd STREET, NEW YORK, N. Y.

OVER FIFTY YEARS OF CONTINUOUS MANUFACTURE — STEAM ENGINES FOR ALL INDUSTRIES

Erie Ball Engines

ERIE BALL ENGINE COMPANY, PITTSBURGH, PA., U. S. A.

For medium and high pressures

ESPECIALLY suitable for large power plants. Steel construction throughout. Straight tubes. All handholes elliptical, their covers internal and removable through their own openings. Unrestricted circulation, permitting forcing of fires with safety and economy.

Send for bulletins on performance

EDGE MOOR IRON COMPANY — Edge Moor, Delaware

EDGE MOOR Water Tube BOILERS

FOR INCREASED FUEL ECONOMY

LADD

INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

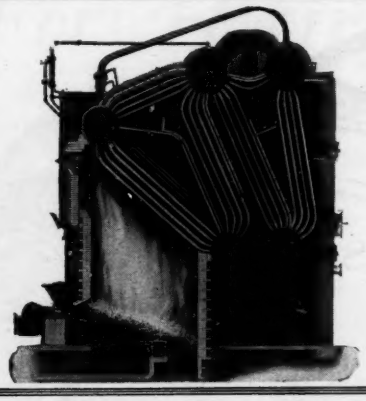
BOILERS

Ladd Water Tube Boiler Co.

International Combustion Bldg.
200 Madison Ave., 35th to 36th St.
New York, N. Y.

First National Bank Building
Pittsburgh, Pa.

A Subsidiary of International Combustion Engineering Corporation

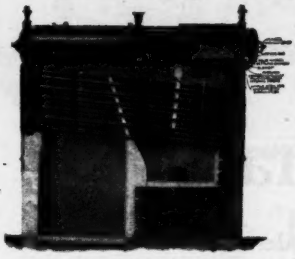


The C-H Multipass Water Tube Boiler

This boiler is made in sizes from 200 to 3000 hp. and for pressures up to 600 lbs. It has two distinct water circulating systems. All precipitates accumulate in the back bottom drum. It carries high overloads with steady water level and low flue gas temperatures. Write for catalog MP-4.

THE CASEY-HEDGES COMPANY
CHATTANOOGA, TENN.
Branches in All Principal Cities

UNION WATER TUBE BOILERS



Standard longitudinal drum boiler. Also made in cross drum type.

UNION BOILERS are built in longitudinal drum, cross drum and vertical bent tube types for practically all operating pressures and sizes.

Designed and built by an organization backed by forty years experience in the manufacture of high pressure steam boilers exclusively, in a modern and specially equipped plant.

Sales offices in principal cities are at your service.

UNION IRON WORKS
ERIE PA.

Also made with third upper drum and economizer element as well as integral front water wall (patented).

WATER TUBE BOILERS—
ALL TYPES, SIZES, PRESSURES

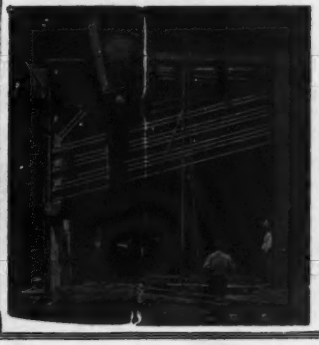
INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

HEINE BOILERS

Heine Boiler Company
INTERNATIONAL COMBUSTION BUILDING
200 MADISON AVENUE
NEW YORK

A Subsidiary of International Combustion Engineering Corporation

SPRINGFIELD BOILERS



Sectional
All Steel
Water Tube

Springfield Boiler Co.
Springfield, Ill.

OFFICES:

Chicago	Cincinnati
New York	Minneapolis
Boston	Duluth
Philadelphia	Kansas City
Pittsburgh	New Orleans
Richmond	Dallas
Atlanta	Los Angeles
Detroit	San Francisco
	Seattle

Remarkable Efficiencies

Shown by

BADENHAUSEN (Patented)
Boilers
Preheaters
Superheaters
Water Cooled Furnace Walls

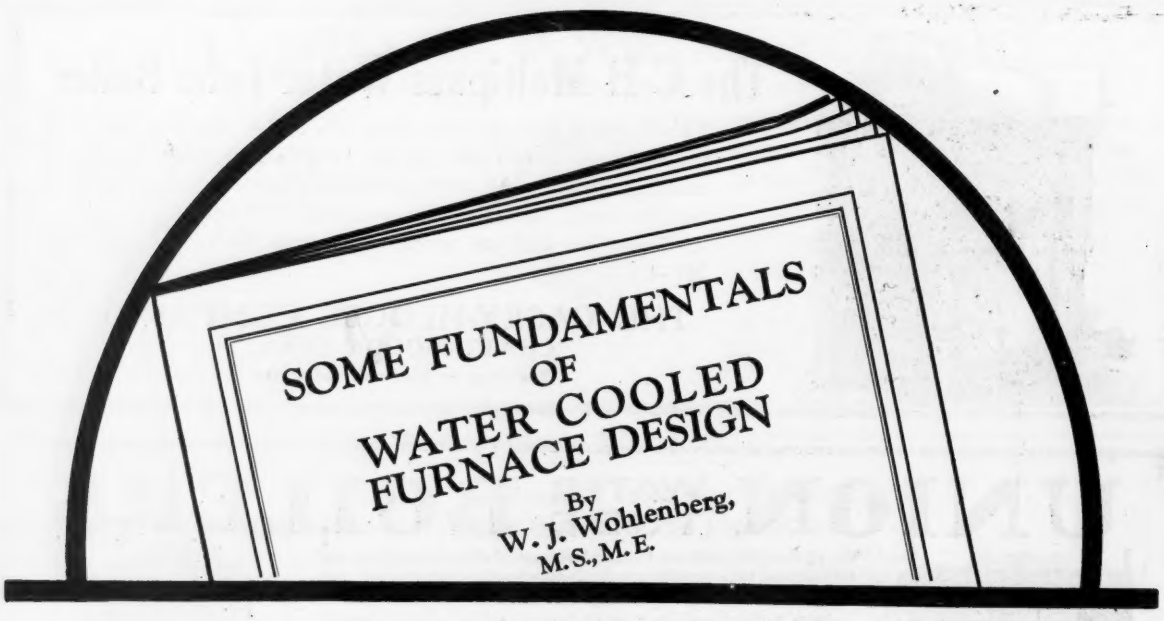
Each a unit in itself, yet an integral part of the boiler proper
Surveys and Tests by outside Engineers forwarded on request

BADENHAUSEN CORPORATION
General Office and Works
Cornwells Heights, Bucks County, Pa.

WICKES BOILERS

Horizontal Cross Drum Boilers
Vertical Water Tube Boilers
Inclined Curved Tube Boilers
Horizontal Tubular Boilers

THE WICKES BOILER CO.
SALES OFFICES:
NEW YORK, 521 FIFTH AVE. PITTSBURG, 1212 EMPIRE BLDG.
DETROIT, GENERAL MOTORS BLDG.
CHICAGO, 20 N. CLARK ST. SEATTLE, 720 FERRY BLDG.
SAGINAW, MICH.



Water Cooled Furnaces

are becoming an increasingly important factor in the modern steam generating plant—especially with the ever growing use of Pulverized Coal. We offer Prof. Wohlenberg's latest contribution to the subject of Furnace Design, in the belief that it will be of assistance to those officials and operators most interested in the power plant.

Prof. Wohlenberg's article deals with the outstanding types of water cooled furnaces and should make a valuable addition to your files. The coupon is for your convenience.

ERIE CITY IRON WORKS
ERIE, PENN'A, U.S.A.

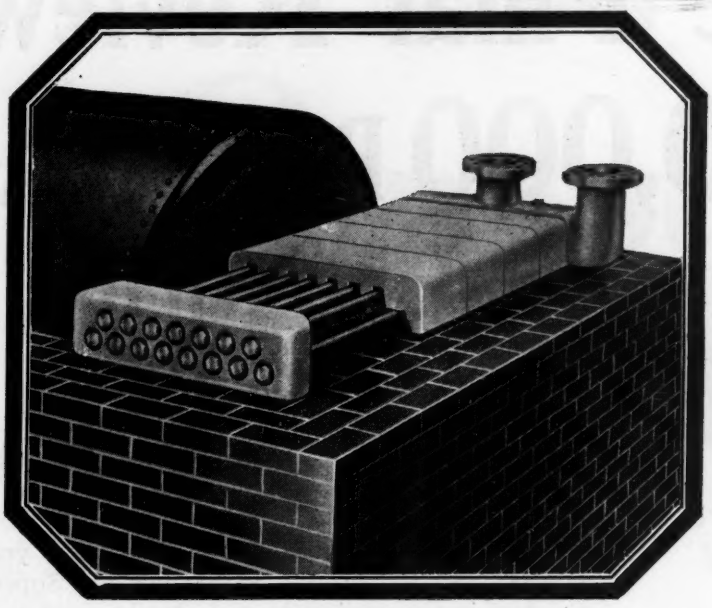
Please send me a copy of Prof. Wohlenberg's recent article

Name _____
Position _____
Concern _____
Address _____

2

For Horizontal Return Tubular Boilers —use the

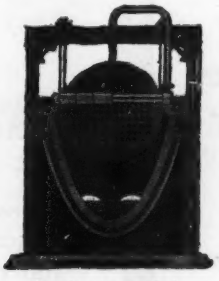
MAR·LEY STEAM SUPERHEATER !



Offering These IMPORTANT ADVANTAGES

It is now possible for steam plants equipped with horizontal return tubular boilers to secure efficient superheater equipment. The value of superheated steam can not be questioned—as all large steam plants have elaborate equipment of this type. The Marley Steam Superheater for horizontal return tubular boilers is of a very practical design —and offers the many important advantages listed below.

- Makes a marked reduction in fuel bills.
- Increases existing horsepower.
- Acts as the rear arch.
- Eliminates water in high pressure steam lines.
- Better lubrication of steam cylinders.
- Low in first cost.
- Improves overall efficiency.
- Produces dry steam, which is acknowledged best.
- Effects a material reduction in pressure drop and radiation losses in high pressure steam lines.



Showing rear end view of the Marley Steam Superheater installed.

- A more uniform operation of oil burners.
- No changes to setting or piping beyond boiler required.
- Easily installed in existing plants.
- Applied to boilers using any kind of fuel.
- Of long life, being installed out of the high temperature area.
- Easily drained, having plugs conveniently located.
- Easy to inspect, clean, to roll or renew tubes.
- Ready for installation when received.

MANY NOW IN USE

A large number of Marley Steam Superheaters for horizontal return tubular boilers are in use today throughout the country. Expressions from owners as to their satisfaction are frequently received. Why not let us tell you more. Write us today.

POWER PLANT EQUIPMENT CO.
COCA COLA BLDG. KANSAS CITY, MO.

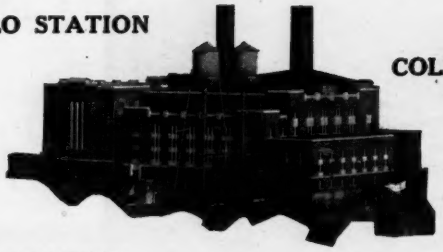
MARLEY PPE PRODUCTS

A Few Users of "Superheated Air"

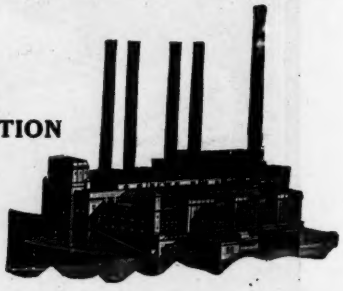
Norton Company, Worcester, Mass.
Philadelphia Electric Co., Chester, Pa.
Narragansett Electric Lighting Co., Providence, R. I.
American Gas & Electric Co., Rockford, Ill.
American Gas & Electric Co., Atlantic City, N. J.
American Gas & Electric Co., Philo, Ohio
Roxana Petroleum Corp., Roxana, Ill.
Chesapeake Corporation, West Point, Va.
Bogalusa Paper Co., Bogalusa, La.
American Gas & Electric Co., Pittston, Pa.
Standard Oil Co., Bayway, N. J.
Phoenix Utility Co., Pine Grove, Pa.
Phoenix Utility Co., Ft. Lauderdale, Fla.
Byllesby Eng. & Management Corp., Green Bay, Wis.
Waukegan Generating Co., Waukegan, Ill.
Phoenix Utility Co., Sanford, Fla.
American Gas & Electric Co., Cabin Creek, W. Va.
Byllesby Eng. & Management Corp., San Diego, Cal.
Northwestern Public Service Co., Mitchell, S. D.
City of St. Louis, St. Louis, Mo.
Byllesby Eng. & Management Corp., Harrah, Okla.
Honolulu Iron Works Co., Central Cuba.
American Gas & Electric Co., Atlantic City, N. J. (Repeat Order)
Viscose Company, Parkersburg, W. Va.
Tannin Corp., Wilmington, Del.
Fitchburg Paper Co., Fitchburg, Mass.
West Virginia Pulp & Paper Co., Covington, Va.
Semet-Solvay Co., Harriet, N. Y.
Algonquin Paper Co., Ogdensburg, N. Y.
Packard Motor Car Co., Detroit, Mich.
Hummel-Ross Fibre Corp., Hopewell, Va.
Hillsborough Mills, Wilton, N. H.
Byllesby Eng. & Management Corp., Colfax Station, Springdale, Pa.
Byllesby Eng. & Management Corp., San Diego, Cal. (Repeat Order)
Carnegie Steel Co., Clairton, Pa.
Consumers Power Co., Zilwaukee, Mich.
Consumers Power Co., Nashville, Tenn.
City of Jacksonville, Jacksonville, Fla.
Byllesby Eng. & Management Corp., Harrah, Okla. (Repeat Order)
Iowa Railway & Light Co., Cedar Rapids, Iowa
Public Service Production Co., Kearny, N. J.
Honolulu Iron Works, Los Mochis, Mex.
American Gas & Electric Co., Scranton, Pa.
Kohler Co., Kohler, Wis.

The Final Review of 750,000 B. H. P. now installed

PHILO STATION



COLFAX STATION



Recovers 70% of Stack Heat

THE short space of less than three years has seen the growth in the use of "Superheated Air" in the engineering field to the total of 750,000 boiler horsepower.

"SUPERHEATED AIR" is air heated to 400 to 650 deg. F., as is commercially possible by means of the REGENERATIVE COUNTER-FLOW principle of the Ljungström Air Preheater only.

This record has three important factors that are more significant than even the grand total of sales. They are:

First, Ljungström Air Preheaters have sold themselves—and reorders have followed—on their record with many of the largest and most important central stations and industrial plants.

Second, the most eminent consulting and construction engineers in the country have specified and respecified Ljungström Air Preheaters.

Get our Guarantee on your Plant

NARRAGANSETT STATION

SAN DIEGO STATION

# of 1927 shows more than

of The Ljungström AIR PREHEATER

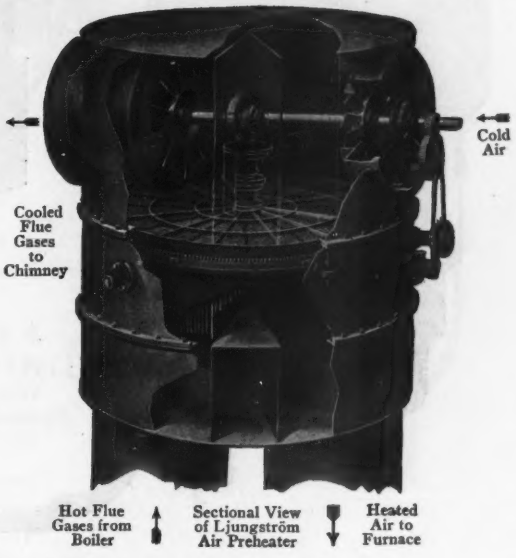
Reg. U.S.Pat. Office.

Made in Sizes up to 5000 B.HP.

Third, important new power plants, built without Ljungström Air Preheaters in the first sections, have since provided this means of greatly increasing economy in addition to these stations.

As the year closes, majority opinion, as expressed by orders and reorders, shows the decided trend toward standardization on "Superheated Air" to improve operating conditions, obtain more capacity from the same boilers and to reduce fuel consumption.

Get the facts! Let us study your plant, whether it is large or small, and give you our guarantee. Write us freely.


Cold Air
Cooled Flue Gases to Chimney
Hot Flue Gases from Boiler
Sectional View of Ljungström Air Preheater
Heated Air to Furnace

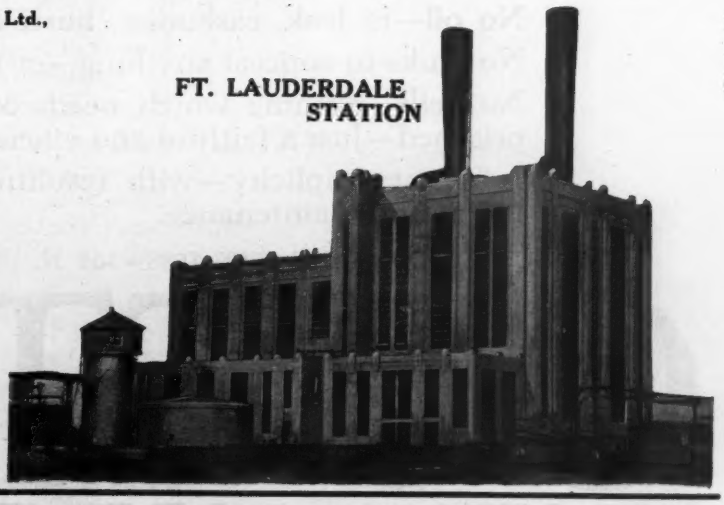
Saves 10 to 15% of the fuel bills

The Air Preheater Corporation

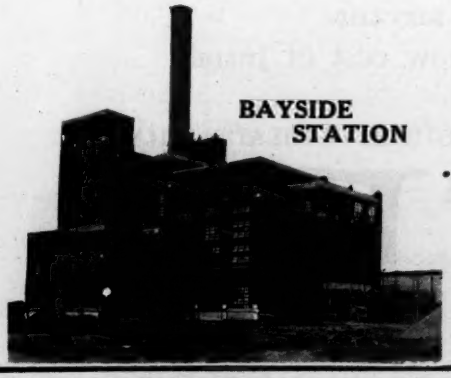
25 Broadway, New York

Canadian Licensees: Lammers & Maase, Ltd., 1075 Beaver Hall Hill, Montreal

FT. LAUDERDALE STATION



BAYSIDE STATION



Immersed in AIR

for SAFETY AND RELIABILITY

A PROMINENT CHICAGO INSTALLATION

A 5000 ampere I-T-E type L G Circuit Breaker for 600 volts or less alternating current service. This breaker is equipped with Overload, Dalite (direct acting inverse time limit), and Autoite (non-closable on overload) features.

I-T-E AIR BREAK has definite advantages not present in the oil breaker

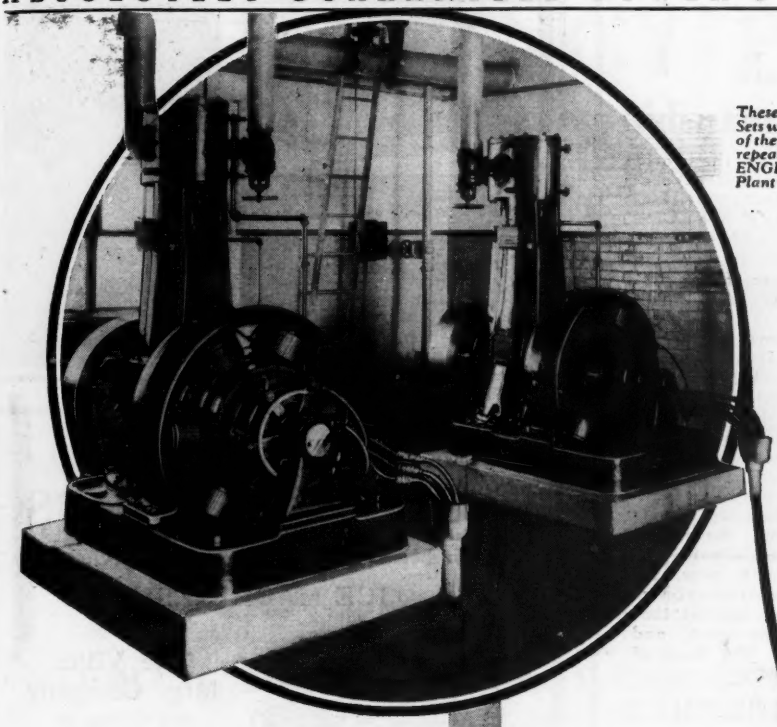
1. No oil—to leak, carbonize, burn or explode—Just air.
2. No tanks to conceal anything—or the lack of it.
3. No cells—nothing which needs or deserves to be imprisoned—Just a faithful and efficient servant.
4. Inherent simplicity—with resulting low cost of installation and maintenance.

THE CUTTER COMPANY—EST. 1888—505 N. 19th STREET—PHILADELPHIA

CUTTER

U-RE-LITE I-T-E CIRCUIT BREAKERS

ABSOLUTELY GUARANTEED POWER PLANT EQUIPMENT



These two ENGBERG 20 Kilowatt Generating Sets were installed in the Weston, Michigan, Plant of the Page Dairy Company of Toledo, Ohio, as a repeat order, due to the performance of an ENGBERG 15 Kilowatt Unit in the Whitehouse Plant of this same Company.

ENGBERG Generating Sets are insisted upon by first-class engineers because they are so dependable, economical, and convenient to operate. Note their simplicity, compactness and clean-cut appearance.

ANOTHER Repeat Order and *Unqualified* Recommendation

H. A. PAGE, President of the Page Dairy Company, has written us as follows: "We are very well pleased with the two ENGBERG 20 Kilowatt Generating Sets at our Weston Plant and can recommend these machines to anyone in the market for such equipment."

This is but an example of the hundreds of favorable comments and repeat orders which we are continually receiving from most responsible corporations in all lines of industry, and is the direct result of thorough design and construction.

Improvements resulting from more than thirty years of intensive study and testing insure greatest convenience for the operator, a genuine guarantee of dependable, economical service, and are responsible for the selection of ENGBERG in first-class installations.

ENGBERG'S ELECTRIC & MECHANICAL WORKS
826 Vine Street, St. Joseph, Michigan, U. S. A.

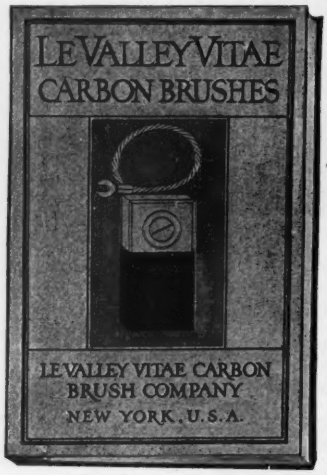
ENGBERG

Engberg
THE STANDARD FOR EFFICIENCY-DURABILITY-SERVICE

ENGINES
GENERATING SETS
GENERATORS
MOTORS
SWITCHBOARDS

THE RESULT OF THIRTY YEARS PRACTICAL EXPERIENCE

All the Experience
All the Good Materials
All the Skilled Workmanship



in all the world may fail to produce a satisfactory Carbon Brush for the service you require if the producer of that brush doesn't know your requirements and build the brush to meet them.

We start right by finding out exactly what you need.

With our facilities and "know how," the rest is not difficult.

Ask, now, for the Data Sheet that insures that right start, and for The Book of the Better Carbon Brushes shown here.

LE VALLEY VITAE CARBON BRUSH CO.

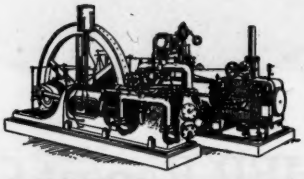
General Office:
100 East 45th Street, New York, N. Y.
Carbon Brushes—Graphite Brushes—Electro-Graphitic Brushes
Metallized Graphite Brushes of surpassing quality

HIGH GRADE

Corliss Engines

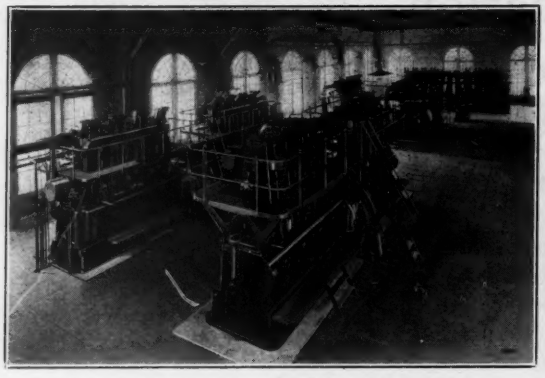
for belted or direct connected service

ICE MACHINES



Built by

The Vilter Mfg. Company
972 Clinton St.
Milwaukee, Wis.
Established 1867
Chicago Office
731 Monadnock Block



San Antonio Adds Another 1000-hp. Oil Engine

Successful performance has again won a repeat order. The San Antonio Portland Cement Company of San Antonio, Texas, recently installed another Ingersoll-Rand PR Oil Engine of 1000 b.hp. This constitutes the second repeat order since the original installation.

There are now five PR Oil Engines in the San Antonio Plant, these units having a total capacity of 4000 b.hp. Each engine is direct-connected to a generator. The power is used for the plant load.

INGERSOLL-RAND COMPANY — 11 BROADWAY, NEW YORK, N.Y.
A. S. CAMERON STEAM PUMP WORKS
Offices in Principal Cities the World Over
FOR CANADA REFER — CANADIAN INGERSOLL-RAND CO. LIMITED 150 ST. JAMES ST. MONTREAL, QUEBEC

Ingersoll-Rand

120-SOE

The Most Economical Steam Engine

"UNIVERSAL UNAFLOW"

Built only by
Skinner Engine Co.
ERIE, PENNA.

Engineers who recognize and demand the greatest efficiency insist upon

IDEAL Commutator Resurfacers

More than 14,000 now use IDEALS exclusively.

Write for our 10 day FREE TRIAL *offer.*

Ideal Commutator Dresser Co.
1033 Park Ave., Sycamore, Illinois

Ideal Commutator Dresser Co., 1033 Park Ave.
Sycamore, Ill.
Gentlemen: Please send me details of your free trial offer.

Name .....

Address .....

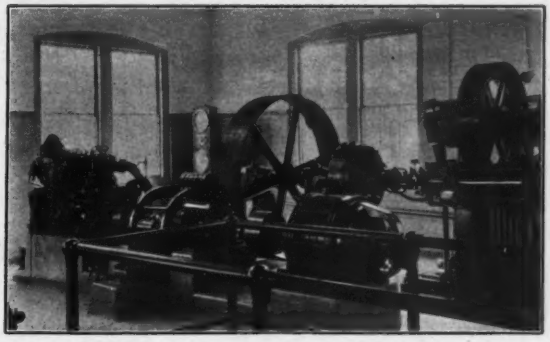
City..... State.....

1227

EMERGENCY POWER
for the Piston Pump

Centrifugals, Electric generators, piston pumps and every conceivable emergency unit most advantageously can be powered with

Sterling High Duty Internal Combustion Engines



Bridgewater, Mass., Sterling 4 cylinder 85 H. P. 1200 R. P. M. engine belted to pulley of 450 GPM 150 lb. pressure piston pump. Engineering and installation by F. A. Mazzur & Co., Boston, Mass.

STERLING ENGINE COMPANY, Dept. C-10, Buffalo, N.Y., U.S.A.

10 to 3000 H.P. for standby and peak load.
900-1200-1400 R. P. M.

THE TERRY TURBINE

More than 10,000 Terry Turbines now in operation; also reduction gears and shaft couplings. There is a type to meet your particular needs. Terry engineers are available for consultation and advice on any problem involving the use of a turbine. Write for information, stating your steam conditions and power requirements.

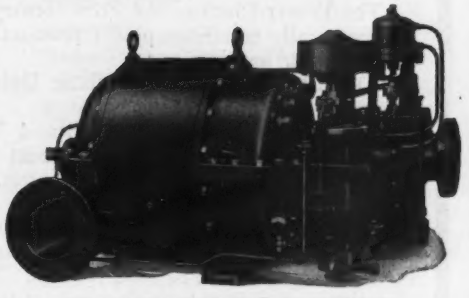
The Terry Steam Turbine Co.
Hartford, Conn.

TROY ENGINES

"Only Steam Engines" from 2 to 200 B.H.P. *"Good Engines Only"*

TROY ENGINE & MACHINE CO.
Troy, Pennsylvania
Chicago Office: 118 West Ohio St.
Riley Engineering & Supply Co., Ltd.
360 Dufferin St., Toronto, Can.

MOORE



Multi-stage Auxiliary Drive Turbine

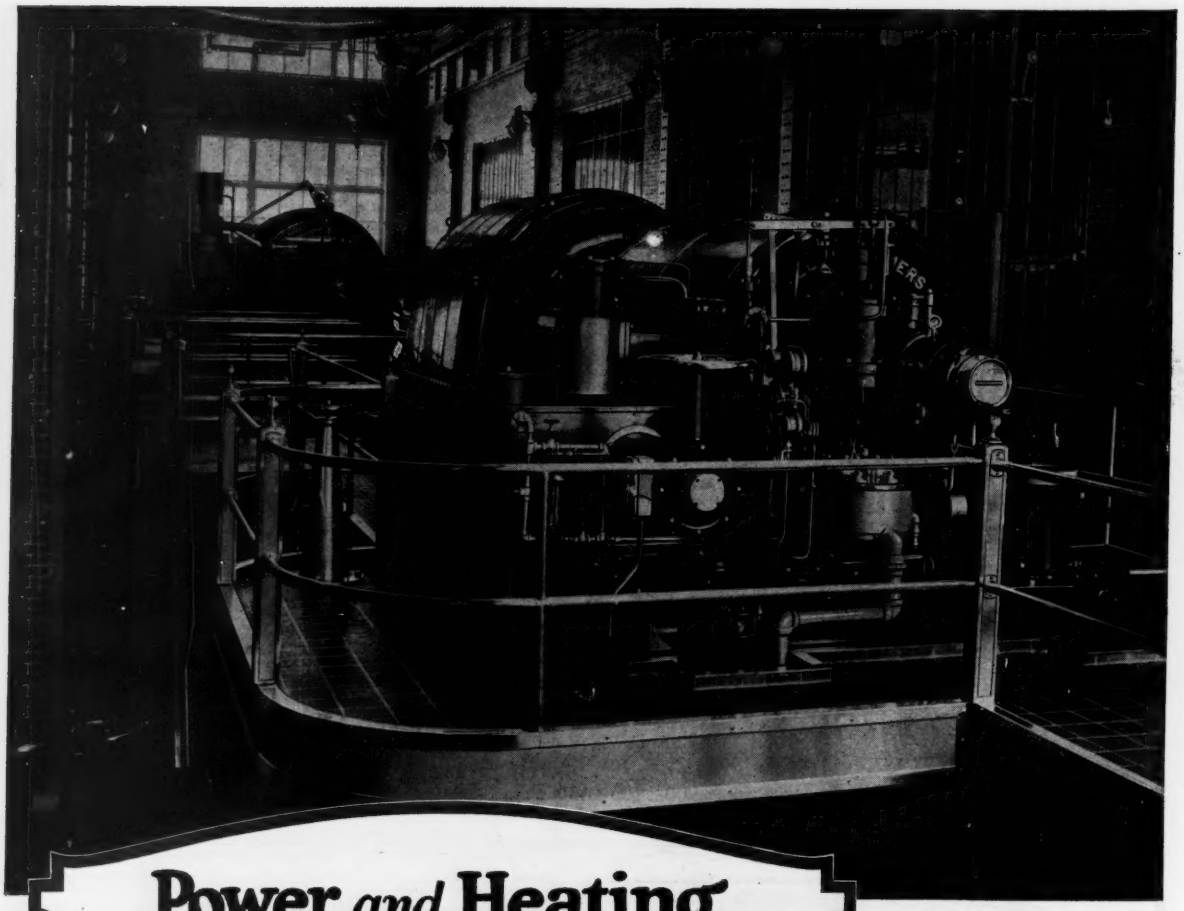
LONGER BLADE LIFE

Steam velocities in multi-stage turbines are proportionately lower than in single stage. As blade wear decreases very rapidly with decrease of steam velocities the blade life of multi-stage turbines is much longer than that of the single stage.

With the higher steam pressures and temperatures used today this feature becomes very important.

Steam Turbines Centrifugal Pumps Reduction Gears

MOORE STEAM TURBINE CORPORATION
Wellsville, N. Y.



Power *and* Heating Efficiently Combined

The Power Plant of the Ford factory at Ford City, Ontario, economically combines power production throughout the year with winter heating.

Allis-Chalmers Steam Turbine Units were chosen for this unusual combination.

The two units of 10,000 kw., and 5000 kw. rating, operate normally condensing, but when heat is required, the smaller unit operates with reduced vacuum, the warm circulating water delivering heat to the Plant.

Vacuum is reduced as heat requirements increase and provision is made for extracting additional steam from the larger unit during periods of severe colds. This arrangement meets heating requirements with a minimum of energy loss.

The turbine equipment making this high economy possible is the product of the Allis-Chalmers Organization, which is ready to serve you in any power problem. Additional details will be glady furnished on request.

PRODUCTS

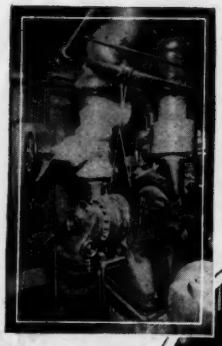
Steam Turbines
Hydraulic Turbines
Electrical Machinery
Steam Engines
Gas Engines
Condensers
Blowing Engines
Oil Engines
Pumping Engines
Centrifugal Pumps
Mining Machinery
Metallurgical Machinery
Crushing Machinery
Cement Machinery
Flour Mill Machinery
Saw Mill Machinery
Air Compressors
Air Brakes
Steam and Electric Hoists
Farm Tractors
Power Transmission Machinery
Timber Preserving Machinery

ALLIS-CHALMERS

MILWAUKEE, WIS., U. S. A.

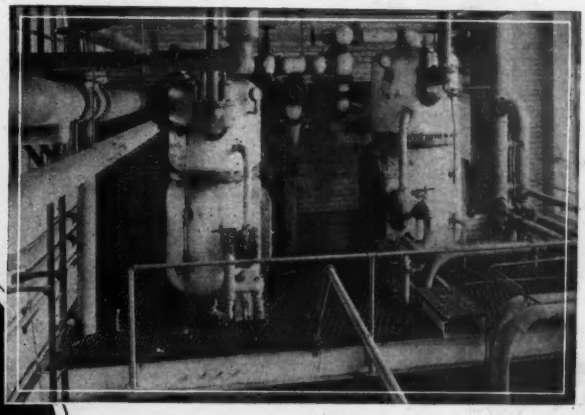
Bethlehem Equipment

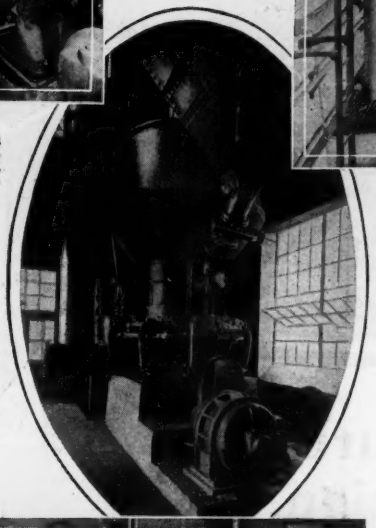
for power plant service



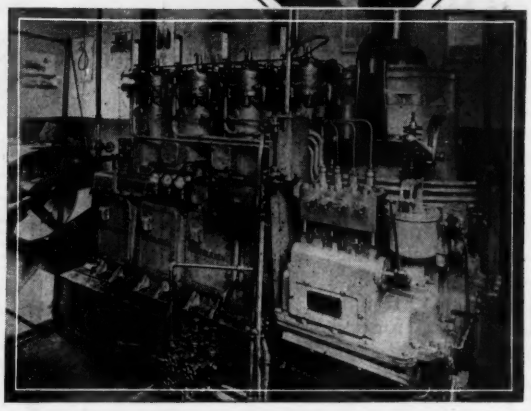
Above:
An installation of No. 75 Bethlehem (Turbine-driven) Boiler Feed Pump.

Right:
An installation of Bethlehem Evaporators.





Right:
A Bethlehem Pulverizer installation.



A Bethlehem Type S Diesel Engine installation.

The accompanying illustrations show some typical installations of Bethlehem Equipment. From these illustrations may be gathered some idea of the wide variety of power plant requirements Bethlehem is prepared to serve.

Bethlehem Equipment is serving the needs of Refrigeration plants, pulverized fuel power plants, hydro electric power plants, and many other power projects throughout the country.

- Mechanical Fuel Oil Burning Systems
- Diesel Engines
- Pulverizers
- Steam Turbine-Driven Single Stage Centrifugal Boiler Feed Pumps
- Motor-Driven Reciprocating General Service Pumps
- Motor-Driven Centrifugal General Service Pumps
- Submerged Tube Evaporators
- Steam-Driven Reciprocating Fuel Oil, Lubricating Oil and Boiler Feed Pumps
- Motor-Turbine-Driven Centrifugal Extraction of Condensate Pumps
- Surface Feed Water Heaters

BETHLEHEM STEEL COMPANY, *General Offices:* **BETHLEHEM, PA.**

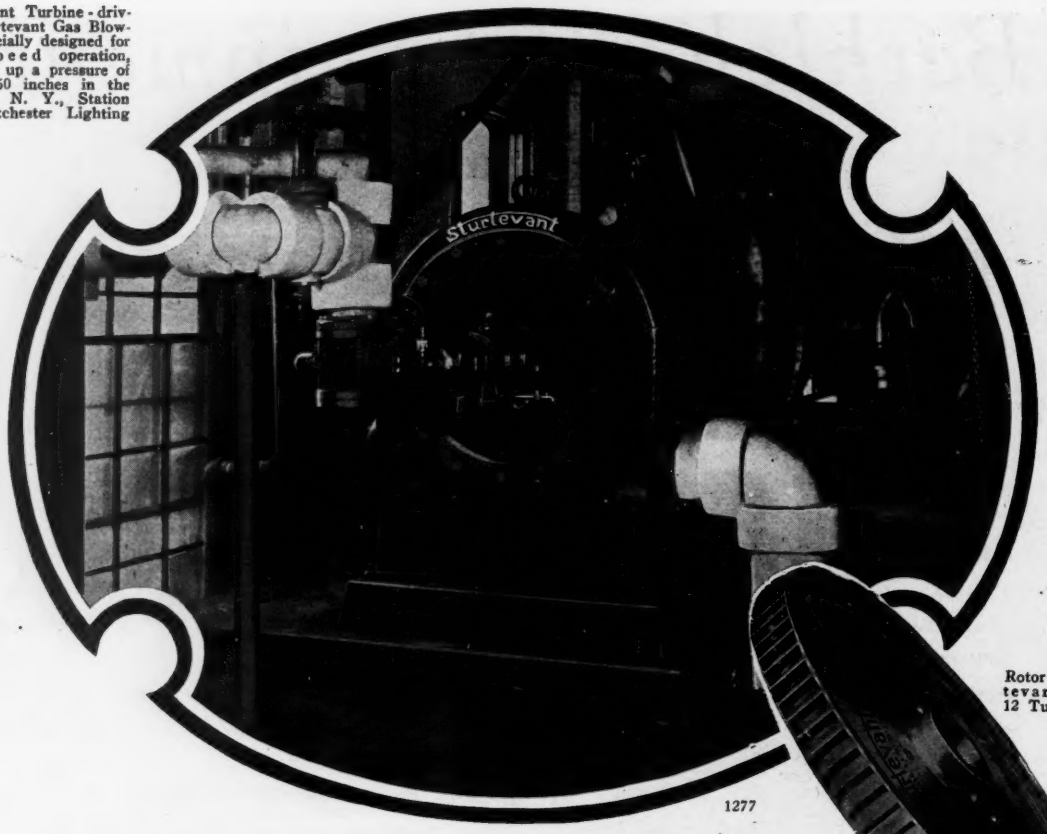
DISTRICT OFFICES

New York Boston Philadelphia Baltimore Washington Atlanta Pittsburgh Buffalo
Cleveland Detroit Cincinnati Chicago St. Louis San Francisco Los Angeles Seattle Portland

Bethlehem Steel Export Corporation, 25 Broadway, New York City, Sole Exporter of our Commercial Products

BETHLEHEM

Sturtevant Turbine-driving Sturtevant Gas Blower, especially designed for low speed operation, building up a pressure of 42 to 60 inches in the Pelham, N. Y., Station of Westchester Lighting Co.



Rotor in Sturtevant Type 12 Turbine.

1277

Sturtevant Steam Turbines —pre-eminent in design, construction and performance

Built with the skill and care which characterize all Sturtevant Products —and reflecting 60 years of experience in building successful power plant equipment—Sturtevant Steam Turbines are the ideal auxiliary drive for plants where greatest flexibility, operating efficiency and economy are demanded.

Some highly important mechanical features distinguish these turbines—large self-aligning bearings—heavy rigid shaft—two entirely independent governors and valves—multiple nozzle control—steam-tight carbon shaft packing and the utmost in simple design and straightforward construction. The rotor is made from a solid steel forging. By a special process, buckets with continuous unnotched edges are milled into the rim, thereby preventing distortion, steam leakage and loss of efficiency.

Our engineers welcome any opportunity to assist you on turbine problems. Write for our Catalog 311

B. F. STURTEVANT COMPANY, HYDE PARK, BOSTON, MASS.

ATLANTA BOSTON BUFFALO CAMDEN CHICAGO CHARLOTTE CINCINNATI CLEVELAND DALLAS DENVER DETROIT HARTFORD INDIANAPOLIS KANSAS CITY LOS ANGELES MINNEAPOLIS MONTREAL NEW YORK CITY PITTSBURGH PORTLAND ROCHESTER ST. LOUIS SAN FRANCISCO SEATTLE TORONTO WASHINGTON

Plants Located at

BERKELEY, CALIF. CAMDEN, N. J. FRAMINGHAM, MASS. GALT, ONTARIO HYDE PARK, MASS. STURTEVANT, WIS.

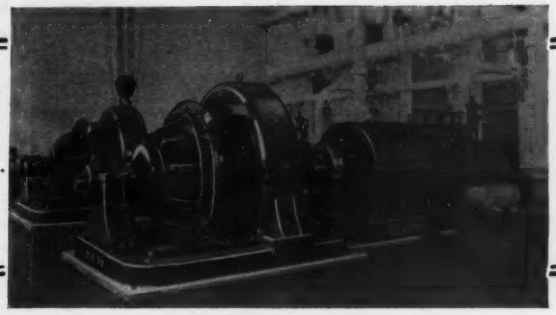
Foreign Representatives: American Trading Co., Tokyo. American Trading Co., Shanghai. Erushaws Docks & Honolulu Iron Works, Manila. Honolulu Iron Works Co., Honolulu, T. H. H. P. Gregory & Co., Ltd., Sydney. Blair, Reed & Co., Ltd., Wellington. International Gen. Elec. Co., Caracas. International Gen. Elec. Co., Bogota. General Machinery Co., Tampico. Pedro Martinto, Inc., Lima. A. E. Barker, Johannesburg

1744

Sturtevant

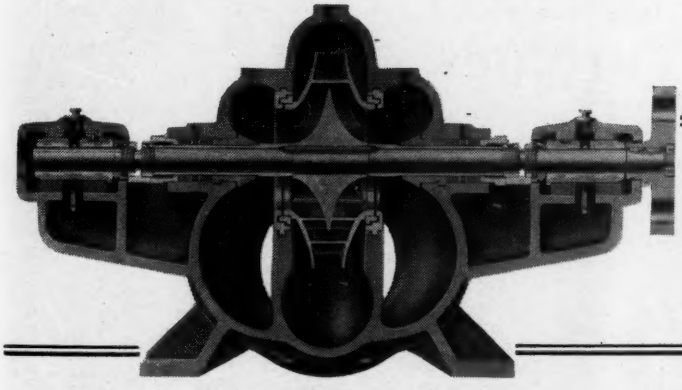
REG. U. S. PAT. OFF.

Cheap Power
from Process Steam



THE two De Laval 1500 K.W. geared turbines installed at the plant of the Mt. Hope Finishing Co., North Dighton, Mass., and shown in the accompanying photograph, have been designed to develop power at high efficiency from steam to be used in manufacturing processes. The turbines operate on steam at 175 lbs. pressure and 100° F. superheat, and exhaust normally against a back pressure of 12 lbs. When the exhaust is not all required at that pressure, a bleeder valve opens automatically and steam is extracted at 80 lbs. for other manufacturing processes. The direct current generators operate at 514 R.P.M., while the turbine speed is 4150 R.P.M., which is favorable to the highest efficiency in power production. Where exhaust or extracted steam can be used for heating, drying, cooking, calendering, etc., power can be produced at extremely low cost. Our engineers will be glad to give you the benefit of their extensive experience in this class of work.

Ask for publication E-1104.



De Laval Pumps
Insure Continuous Operation

Interruptions Cost More Than Good Pumps

IT has always been our aim to produce the most sturdy and trouble-proof pump that it is possible to build. De Laval pumps are characterized by liberal design throughout, bearings and oil reservoirs large, bearings of special tin babbitt and amply distant from pump case to prevent overheating when pumping hot liquids, packing glands large and deep, shafts heavy, with perfect balancing of all rotating parts to prevent vibration, wearing rings of double labyrinth type combining wide clearances with efficient performance, freedom from diffusion vanes and similar accessories subject to rapid deterioration; in fact, the best design that long experience can determine.

De Laval pumps are of the volute diffusor type, resulting in high efficiency over a much wider range of capacity and viscosity than is possible with pumps containing diffusion vanes. Every De Laval pump is fully guaranteed, as to performance, and a complete test is made before the pump leaves the Works.

De Laval Steam Turbine Co.

Trenton, New Jersey

LOCAL OFFICES

Atlanta, Boston, Charlotte, Chicago, Cleveland, Denver, Duluth, Havana, Helena, Honolulu, Houston, Indianapolis, Kansas City, Los Angeles, Montreal, New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., St. Paul, Salt Lake City, San Francisco, Seattle, Spokane, Toronto, Vancouver

667

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Double Helical Speed Reducing Gears, Worm Gears, Hydraulic Turbines, Flexible couplings and Special Centrifugal Machinery

ALPHABETICAL INDEX TO ADVERTISERS

Air Preheater Corp., The....160-161
Allen & Billmyre Co....118
Allen-Sherman Hoff Co., The....148
Allis-Chalmers Mfg. Co....166
American Chimney Corp....143
American Engineering Co....154
American Mond Nickel Co....122
American Schaeffer & Budenberg Corp.... 27
American Steam Pump Co....132
American Steel & Wire Co....139
Armstrong Machine Works.... 15
Associated Business Papers, Inc....113
Atlantic Engrg. Co.... 19
Atlas Valve Co.... 23

Babbitt Steam Specialty Co....123
Babcock & Wilcox Co., The....156
Babcock & Wilcox Tube Co., The....123
Badenhausen Corporation 157
Bailey Meter Co.... 32
Baker Co., Inc., R. H....122
Bethlehem Steel Co....167
Binks Spray Equipment Co....136
Boiler Engineering Co....144
Botfield Refractories Co....139
Bowser & Co., Inc., S. F.... 12
Boylston Steam Specialty Co.... 22
Brady Conveyors Corp., The.... 37
Breuer Electric Mfg. Co....136
Bristol Co., The.... 30
Brown Instrument Co.... 28
Buffalo Forge Co....137
Builders Iron Foundry.... 34
Bundy Steam Trap Co.... 14
Burt Mfg. Co., The.... 13

Cameron Steam Pump Works, A. S. (Ingersoll-Rand Co.) 164
Carborundum Co., The....142
Carling Turbine Blower Co....136
Casey-Hedges Co., The....157
Cement-Gun Co., Inc....143
Chaplin-Fulton Mfg. Co., The.... 26
Chicago Chemical Co.... 35
C. J. Mfg. Co.... 34
Cochrane Corp. 138
Combustion Engineering Corp....152-153
Conneaut Packing Co., The.... 7
Connelly Boiler Co., The D....156
Connery & Co., Inc....147
Connor Co., Inc., The W. B.... 19
Continental Valve & Equipment Co....118
Cooke Seal Ring.... 9
Cook's Sons, Inc., Adam.... 13
Coppus Engineering Corp....133, 136
Crandall Packing Co.... 6
Crane Packing Co.... 6
Cutler-Hammer Mfg. Co., The.... 29
Cutter Co., The....162

Dampney Co. of America, The.... 19
Dart Mfg. Co., E. M....119
Davis Regulator Co., G. M.... 18
Dearborn Chemical Co.... 11
De Laval Steam Turbine Co....169
Detrick Co., M. H....143
Detroit Stoker Co....130
Diamond Power Spec. Co.... 38
Direct Separator Co., Inc., The.... 18
Dixon Crucible Co., Joseph....130

Edge Moor Iron Co....156
Elliott Company 3
Engberg's Elec. & Mech. Wks....163
Engineer Co., The....143
Erie Ball Engine Co....156
Erie City Iron Works....158

Fisher Governor Co., Inc., The.... 30
"Flexitallic" Gasket Co.... 4
Flynn & Emrich Co....130
Foster Wheeler Corp....145
Frederick Iron & Steel Co., The....130
Fuller Lehigh Co....146

Gardner-Denver Co. 133
Garlock Packing Co., The.... 13
Girtanner Engrg. Corp....148
Goetze Gasket & Packing Co.... 8
Golden-Anderson Valve Specialty Co....125
Green Fire Brick Co., A. P....140
Greene, Tweed & Co....4, 18
Grinnell Co., Inc....122
Griscom-Russell Co., The....138

Hagan Corporation 22
Harbison-Walker Refractories Co....139
Hawk-Eye Compound Co.... 37
Heine Boiler Co. 157
Hills-McCanna Co. 13
Hofft Co., The M. A....154
Holmes Metallic Packing Co.... 7
Homestead Valve Mfg. Co....127
Hoppes Manufacturing Co.... 22
Howard Iron Works....122
Huyette Co., Inc., The Paul B.... 38

Ideal Commutator Dresser Co....164
Illinois Engineering Co.... 27
Ingersoll-Rand Co. (Cameron Steam Pump Works, A. S.)....164
Insulating Products Corp....139
International Combustion Engrg. Corp...152-153
Irving Iron Works Co....119

Jeffrey Mfg. Co., The....151
Jenkins Bros. 126
Johns-Manville Corp. 5

See pages 104, 106, 108, 110 and 112 for Classified List of Products and Their Manufacturers.

Kelly Foundry & Machine Co., The....155
Kennedy Valve Mfg. Co., The....129
Keystone Lubricating Co., The.... 13
Kingsford Fdry. & Mach. Wks....133

Laclede Stoker Co. 154
Ladd Water Tube Boiler Co....156
Lagonda Mfg. Co.... 40
Lecourtenay Co. 130
Leeds & Northrup Co.... 34
Le Valley Vitae Carbon Brush Co....164
Link-Belt Co....Back Cover
Littleford Bros. 144
Locke Regulator Co. 27
Lonergan Co., J. E....124
Lunkenheimer Co., The....123

McGraw-Hill Book Co., Inc....119
McLeod & Henry Co....144

Magnolia Metal Co....118
Manistee Iron Works Co....133
Manzel Brothers Co.... 18
Marion Machine, Fdry. & Sup. Co.... 38
Mason Regulator Co.... 22
Metalastic Incorporated 7
Metallo Gasket Co.... 7
Midwestern Engrg. Exposition, Inc....111
Moore Steam Turbine Corp....165
Murray Iron Works Co....164

National Pipe Bending Co....138
National Regulator Co.... 23
National Tube Co....120
National Valve & Mfg. Co....122
Neemes Foundry, Inc....148
Nicholson & Co., W. H.... 14
Northern Equipment Co.... 20
Norton Co. 141
Nugent & Co., Wm. W....118

Obermayer Co., The S....139
Oster Mfg. Co....116
Otis Elevator Co.... 36

Paige & Jones Chemical Co., Inc.... 37
Patterson-Kelley Co., The....138
Penberthy Injector Co.... 37
Pennsylvania Crusher Co. 154
Permutit Co. 37
Pickering Governor Co., The.... 27
Pierce Co., The William B.... 39
Pilley Packing & Flue Brush Mfg. Co.... 38
Pittsburgh Piping & Equipment Co....123
Pittsburgh Valve, Fdry. & Const. Co....123
Platt Iron Works....132
Plibrico Jointless Firebrick Co....139
Pope, Wm. A. 122
Powell Co., The Wm....124
Power Piping Co....123
Power Plant Equipment Co....159
Powers Regulator Co., The.... 27
Prat-Daniel Corp. 144

Quaker City Rubber Co.... 4
Queen's Run Refractories Co., Inc....139
Quigley Furnace Specialties Co., Inc....138

Reading Iron Co....121
Reliance Gauge Column Co., The.... 21
Republic Flow Meters Co.... 33
Richardson Scale Co.... 34
Ross Heater & Mfg. Co., Inc....122
Roto Co., The.... 38
Ruggles-Klingemann Mfg. Co.... 23
Rust Engineering Co., The....144

Sarco Co., Inc.... 16
Schutte & Koerting Co....134
Scully Steel & Iron Co....124
Signboard Section 114-115
Skinner Engine Co....164
Smidth & Co., F. L....131
Smooth-On Mfg. Co. 107
Spray Engineering Co....136
Springfield Boiler Co....157
Squires Co., The C. E.....Inside Front Cover
Standard Oil Co. (Indiana).... 10
Stephens-Adamson Mfg. Co....149
Stephenson Mfg. Co....118
Sterling Engine Co....165
Stone & Webster, Inc....105
Strong, Carlisle & Hammond Co.... 26
Strong-Scott Mfg. Co....150
Sturtevant Co., B. F....168
Sullivan Machinery Co....132
Superheater Co., The....156
Swartwout Co., The.... 17

Taylor Inst. Cos.... 26
Terry Steam Turbine Co., The....165
Texas Co. 109
Toledo Pipe Threading Mach. Co., The....118
Tri-Lok Co., The.... 37
Trimont Mfg. Co. 117
Troy Engine & Machine Co....165

Union Iron Works....157

Vacuum Oil Co.....Front Cover
Vilter Mfg. Co., The....164
Vogt Machine Co., Henry....Inside Back Cover
Vulcan Soot Cleaner Co.... 38

Walworth Co. 128
Warren Steam Pump Co., Inc....130
Webster Mfg. Co. 154
Wellman-Seaver-Morgan Co., The....148
Westinghouse Elec. & Mfg. Co....135
Weston Electrical Inst. Corp.... 31
Wheeler Mfg. Co., C. H....138
Wickes Boiler Co., The....157
Williams Patent Crush & Pul. Co....154
Williams Valve Co., The D. T....125
Wing Mfg. Co., L. J....138
Worthington Pump & Mach. Corp....130
Wright-Austin Co. 19

Yarnall-Waring Co. 24-25
Yeomans Bros. Co. 132